DEPARTMENT OF
ECOLOGY
State of Washington

WASHINGTON STATE
2011 COUNTY EMISSIONS INVENTORY

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Washington State Department of Ecology
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Update Log

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1 Introduction

1.1 Purpose and Background

An emissions inventory is part of an overall air quality management program. Emissions inventories are used in SIP attainment/maintenance planning, air quality forecasting, other air quality planning and rule efforts, public information, point source fee generation, and to meet federal air quality reporting requirements. A complete emissions inventory contains emissions from point, area, mobile and biogenic sources of air pollution.

This document describes the methods and data sources employed to estimate emissions for base year 2011. Emissions were estimated for criteria pollutants, ammonia, and toxic air pollutants as resources allowed. The 2011 inventory will be used to update the Northwest International Air Quality Environmental Science and Technology Consortium (NW-AIRQUEST)-sponsored Air Indicator for Public Access and Community Tracking (AIRPACT) air quality forecasting system inventory, fulfill federal reporting requirements, and to support many other end uses over the next three years.

Discretion should be used when comparing results between different inventory years. What appear to be emissions changes may instead reflect: (1) changes in emissions estimation models, methodologies, and /or emission rates, (2) sources and/or pollutants included in the inventory, and (3) correction of errors in prior inventories.

1.2 Pollutants and Sources

The inventory includes estimates of criteria pollutants, ammonia (NH_3), and some air toxics for sources as shown in the table below. Criteria pollutants include carbon monoxide (CO), nitrogen oxides (NO_X), particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2), and volatile organic compounds (VOC) as ozone precursors.

Table 1-1. Sources and Pollutants Inventoried

Source Category	Pollutants
Point sources	CO, NH_3, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Small point sources treated as area sources	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC
Onroad mobile	CO, NH_3, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Road dust	PM_{10}, $PM_{2.5}$
Locomotives	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC
Ships	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC
Other nonroad mobile sources	CO, NH_3, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC
Wood stoves and fireplaces	CO, NH_3, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Residential fuel use, exc wood stoves	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Agricultural tilling	PM_{10}, $PM_{2.5}$
Agricultural harvesting	PM_{10}, $PM_{2.5}$
Gasoline stations	VOC, toxics
Architectural surface coating	VOC, toxics

Table 1-1. Sources and Pollutants Inventoried	
Source Category	**Pollutants**
Consumer/commercial solvents	VOC, toxics
Fertilizer application	NH_3
Livestock waste	NH_3
Silvicultural burning	CO, NO_X, PM_{10}, $PM_{2.5}$, VOC
Agricultural burning	CO, NO_X, PM_{10}, $PM_{2.5}$, VOC
Residential trash burning	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Residential yard waste burning	CO, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Structure fires	CO, NO_X, PM_{10}, $PM_{2.5}$, VOC, toxics
Vehicle fires	CO, NO_X, PM_{10}, $PM_{2.5}$, VOC
Wildfires	CO, NH_3, NO_X, PM_{10}, $PM_{2.5}$, SO_2, VOC, toxics
Biogenic	CO, NO_X, VOC, toxics
Soils	NH_3

Currently, EPA has not released all of the toxics emission factors for all categories; therefore, toxics have not been estimated for several categories which have toxics components. Toxics for the following categories may be added at a later date as the data becomes available: Locomotives, Ships, Other Nonroad Mobile Sources, Silvicultural Burning, and Agricultural Burning.

1.3 Spatial Resolution

The inventory was developed at the county level.

1.4 Temporal Resolution

The inventory was developed for each of the four seasons, and the annual total. Generally, Dec-Feb was classified as winter, Mar-May as spring, Jun-Aug as summer and Sep-Nov as fall.

Abbreviations used are tpy (tons per year) and tps (tons per season).

2 Statistics Used Throughout the Inventory

2.1 County Demographics

Emissions estimation methods for many source categories rely on surrogate parameters as indicators of activity. Population and housing units are two of the most common. Population for 2011 was available through the State Office of Financial Management (OFM).[1] Occupied housing units for 2011 were requested from OFM and were provided.

Table 2-1. Population and Housing, 2011						
County	Population 2011			2011 Occupied Housing Units		
	Incorp.	Unincorp.	Total	Incorp.	Unincorp.	Total
Adams	9,990	8,960	18,950	3,236	2,509	5,745
Asotin	8,455	13,195	21,650	3,691	5,565	9,256
Benton	144,880	33,020	177,900	54,874	11,230	66,104
Chelan	42,200	30,500	72,700	16,512	11,354	27,866
Clallam	29,205	42,395	71,600	13,017	18,385	31,402
Clark	223,390	204,610	428,000	86,710	72,129	158,839
Columbia	2,665	1,435	4,100	1,148	622	1,770
Cowlitz	58,475	44,225	102,700	23,595	16,720	40,315
Douglas	18,060	20,590	38,650	6,595	7,359	13,954
Ferry	1,080	6,520	7,600	492	2,707	3,199
Franklin	66,835	13,665	80,500	19,348	4,235	23,583
Garfield	1,415	835	2,250	637	346	983
Grant	49,705	40,395	90,100	16,803	13,495	30,298
Grays Harbor	44,345	28,555	72,900	17,998	10,558	28,556
Island	25,100	53,700	78,800	10,078	22,794	32,872
Jefferson	9,180	20,870	30,050	4,581	9,552	14,133
King	1,657,335	285,265	1,942,600	689,365	104,723	794,088
Kitsap	82,505	171,395	253,900	32,958	64,699	97,657
Kittitas	22,985	18,315	41,300	9,378	7,356	16,734
Klickitat	6,380	14,120	20,500	2,670	5,744	8,414
Lewis	30,740	45,260	76,000	12,072	17,826	29,898
Lincoln	5,490	5,110	10,600	2,317	2,122	4,439
Mason	9,855	51,245	61,100	3,568	20,359	23,927
Okanogan	16,395	24,805	41,200	6,444	10,068	16,512
Pacific	6,830	14,070	20,900	2,821	6,662	9,483
Pend Oreille	3,210	9,790	13,000	1,357	4,122	5,479
Pierce	430,040	372,110	802,150	171,245	130,171	301,416
San Juan	2,180	13,720	15,900	1,033	6,642	7,675
Skagit	69,145	48,255	117,400	26,591	19,131	45,722
Skamania	2,465	8,685	11,150	1,072	3,477	4,549
Snohomish	412,565	304,435	717,000	158,994	110,699	269,693
Spokane	335,937	136,713	472,650	136,834	50,964	187,798
Stevens	9,654	33,946	43,600	4,166	13,191	17,357
Thurston	118,270	135,830	254,100	49,098	52,259	101,357
Wahkiakum	530	3,470	4,000	250	1,495	1,745
Walla Walla	41,985	16,815	58,800	15,683	6,098	21,781
Whatcom	114,565	87,535	202,100	47,245	33,399	80,644
Whitman	38,826	5,974	44,800	14,836	2,656	17,492
Yakima	160,400	84,300	244,700	52,947	28,041	80,988
State Total	**4,313,267**	**2,454,633**	**6,767,900**	**1,722,259**	**911,464**	**2,633,723**

2.2 Meteorological Parameters

Similar to demographics, meteorological parameters are used to estimate emissions for several source categories. Temperature, heating degree days, and rainfall are described here.

Daily minimum and maximum temperatures and precipitation were obtained from several airports with meteorological stations.[2] Monthly averages were calculated from the daily data.

Counties were associated with meteorological stations based upon the predominant areas of traffic and population. County assignments to each meteorological station are shown below.

Table 2-2. County Meteorological Station Assignments

Met Station	Airport Code	County Assignments
WALLA WALLA CITY COUNTY AP	KALW	Columbia, Walla Walla
BELLINGHAM INTL AP	KBLI	Whatcom
WILLIAM R FAIRCHILD	KCLM	Clallam, Jefferson
THE DALLES MUNICIPAL ARPT	KDLS	Klickitat
WENATCHEE/PANGBORN	KEAT	Chelan, Douglas
ELLENSBURG/BOWERS	KELN	Kittitas
FRIDAY HARBOR	KFHR	San Juan
SPOKANE INTERNATIONAL AP	KGEG	Spokane
HOQUIAM AP	KHQM	Grays Harbor, Pacific
KELSO-LONGVEIW AWOS	KKLS	Cowlitz, Lewis, Wahkiakum
LEWISTON NEZ PERCE CNTY AP	KLWS	Asotin, Garfield
MOSES LAKE/GRANT CO	KMWH	Adams, Grant, Lincoln
OLYMPIA AIRPORT	KOLM	Thurston
OMAK	KOMK	Ferry, Okanogan, Pend Oreille, Stevens
SNOHOMISH CO	KPAE	Island, Skagit, Snohomish
PORTLAND INTERNATIONAL AP	KPDX	Clark, Skamania
PASCO/TRI-CITIES	KPSC	Benton, Franklin
PULLMAN/MOSCOW RGNL	KPUW	Whitman
BREMERTON NATIONAL	KPWT	Kitsap
SEATTLE-TACOMA INTL AP	KSEA	King, Pierce
SHELTON/SANDERSON	KSHN	Mason
YAKIMA AIR TERMINAL	KYKM	Yakima

Table 2-3. Average Monthly Minimum Temperature, 2011

Call*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KALW	32.4	31.5	38.6	39.2	46.2	53.7	58.8	62.9	57.2	47.2	36.0	28.4
KBLI	35.9	32.8	39.7	39.3	45.4	52.3	53.5	54.8	51.3	44.0	36.1	34.3
KCLM	34.2	31.5	35.2	36.4	43.0	48.2	51.8	51.7	49.3	42.8	36.1	32.7
KDLS	33.3	30.7	36.0	40.0	46.8	54.0	57.6	61.0	54.1	47.3	35.0	28.9

Table 2-3. Average Monthly Minimum Temperature, 2011												
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
KEAT	24.3	24.9	33.1	36.1	45.2	52.7	57.3	61.4	54.6	42.8	28.4	24.0
KELN	24.7	24.9	32.1	33.5	42.4	50.2	53.8	56.9	48.5	40.9	27.6	21.7
KFHR	37.0	33.5	40.4	37.9	43.3	48.4	49.0	48.9	49.0	43.6	36.9	36.5
KGEG	22.1	21.6	31.1	32.1	40.7	47.0	52.3	55.8	49.8	39.1	27.3	22.6
KHQM	38.7	35.3	40.2	39.2	44.2	51.3	52.7	53.6	52.2	46.1	37.6	35.6
KKLS	36.9	33.5	39.8	39.1	43.9	50.8	53.5	55.3	52.6	47.0	38.3	33.6
KLWS	29.9	27.3	34.5	36.3	43.9	50.7	54.4	59.2	53.4	44.1	31.6	25.3
KMWH	23.3	24.4	33.5	33.7	42.3	50.7	53.7	54.4	49.3	39.5	24.8	20.7
KOLM	33.7	29.0	34.6	33.9	38.6	46.1	48.2	48.5	46.2	41.7	30.9	29.2
KOMK	21.3	21.4	32.3	31.9	42.3	47.4	50.8	54.9	47.1	35.4	22.9	20.5
KPAE	37.5	34.6	40.2	39.4	45.8	51.0	53.4	55.2	55.1	47.5	38.4	36.0
KPDX	36.0	33.4	38.3	38.9	44.4	52.2	55.7	58.7	55.6	48.5	37.7	32.2
KPSC	29.7	27.7	35.1	36.4	43.2	52.5	53.7	56.4	49.0	43.3	28.5	24.7
KPUW	26.1	24.1	33.3	33.3	40.5	46.6	47.1	48.9	46.7	41.0	30.3	25.7
KPWT	32.2	28.2	36.0	30.5	39.9	47.1	49.5	48.5	48.4	40.5	31.5	31.3
KSEA	36.5	33.2	38.2	38.2	44.2	50.4	53.6	55.5	53.6	46.0	35.8	32.8
KSHN	34.4	30.9	36.3	34.6	40.9	47.5	50.4	51.3	48.9	41.6	32.6	32.6
KYKM	23.5	21.5	29.5	29.9	38.8	47.0	48.8	52.7	45.7	37.1	23.0	18.4
* See Table 2-2 for Corresponding Met Station Names.												

Table 2-4. Average Monthly Maximum Temperature, 2011												
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
KALW	44.8	47.4	56.7	57.9	68.0	77.1	86.7	91.1	84.7	63.6	52.8	40.1
KBLI	46.2	45.0	52.5	52.9	60.5	66.9	71.9	74.0	72.3	58.2	49.3	45.4
KCLM	45.3	43.3	48.7	50.0	56.6	61.8	65.7	69.7	70.0	56.2	48.0	44.7
KDLS	47.9	50.0	55.0	60.2	69.5	77.9	85.9	89.5	86.6	66.8	53.0	43.8
KEAT	36.3	41.5	50.8	57.2	68.1	76.3	84.8	89.6	82.8	61.9	45.6	36.8
KELN	38.3	45.4	51.7	56.6	67.6	75.3	83.1	88.1	83.8	63.2	47.8	39.3
KFHR	46.0	45.3	51.9	53.4	60.3	66.6	70.1	72.4	71.4	57.4	49.1	46.5
KGEG	37.9	37.9	47.5	52.7	65.4	72.3	82.1	86.9	81.1	58.8	45.4	36.7
KHQM	47.1	46.0	50.3	51.5	57.6	63.1	66.5	68.4	68.9	59.6	50.9	46.4
KKLS	47.0	46.9	52.3	56.1	63.5	68.8	75.9	78.6	78.6	61.1	50.5	45.5
KLWS	44.5	44.3	55.4	57.5	67.9	77.1	88.1	93.4	87.4	64.6	51.2	43.2
KMWH	36.4	42.6	53.8	59.1	69.5	78.8	85.4	90.8	84.7	63.9	48.2	37.3
KOLM	47.9	46.0	51.9	54.4	62.7	68.9	76.3	78.7	76.9	60.0	50.5	45.8
KOMK	33.8	38.1	51.1	58.2	68.4	77.0	85.3	91.3	84.2	61.3	44.1	36.9
KPAE	45.8	44.3	50.5	51.6	58.6	65.4	70.0	73.1	72.9	57.6	48.5	44.5
KPDX	48.7	48.4	53.7	57.9	64.9	72.6	79.2	82.6	81.6	64.2	53.2	47.3
KPSC	45.0	49.5	57.7	62.6	72.6	81.6	88.9	93.4	86.0	66.3	53.0	40.2

Table 2-4. Average Monthly Maximum Temperature, 2011												
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
KPUW	38.6	36.9	47.7	50.6	62.2	69.5	80.1	85.9	81.4	58.3	44.5	38.4
KPWT	45.0	44.6	49.3	53.0	60.7	66.9	73.7	77.2	74.8	57.3	47.6	44.1
KSEA	47.6	46.9	52.5	53.5	61.9	69.2	76.5	77.7	75.4	59.8	51.1	45.7
KSHN	46.2	44.9	50.2	53.3	61.6	67.6	75.4	77.8	76.0	58.8	48.2	43.8
KYKM	44.4	49.1	55.5	61.3	71.3	80.1	87.2	92.7	86.2	65.6	52.0	42.7
* See Table 2-2 for Corresponding Met Station Names.												

Table 2-5. Precipitation Days Greater Than 0.01 Inches, 2011													
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
KALW	13	7	24	13	14	9	3	3	2	11	13	5	**117**
KBLI	23	14	21	22	17	12	13	5	7	18	17	19	**188**
KCLM	18	13	17	13	8	1	4	1	5	5	12	9	**106**
KDLS	12	7	18	9	10	2	4	0	1	14	12	7	**96**
KEAT	5	3	15	1	9	4	4	0	0	8	8	3	**60**
KELN	16	12	20	4	11	5	3	0	2	11	11	8	**103**
KFHR	20	13	24	18	16	14	13	11	16	23	16	18	**202**
KGEG	16	9	22	18	16	8	7	0	4	14	11	9	**134**
KHQM	24	19	30	25	22	18	13	5	11	19	22	21	**229**
KKLS	15	16	22	18	15	13	10	0	6	12	13	7	**147**
KLWS	11	13	20	15	19	11	5	2	2	11	9	5	**123**
KMWH	10	2	13	5	11	6	2	0	2	6	5	3	**65**
KOLM	20	19	25	20	16	10	9	5	11	18	18	13	**184**
KOMK	6	5	18	4	15	7	7	0	2	6	10	5	**85**
KPAE	20	16	27	24	18	18	13	1	5	22	19	18	**201**
KPDX	19	21	29	28	24	13	11	3	11	17	21	14	**211**
KPSC	10	5	15	8	11	5	3	1	1	12	6	3	**80**
KPUW	14	16	23	17	18	12	3	0	4	12	14	7	**140**
KPWT	13	10	21	17	14	9	6	0	7	8	9	7	**121**
KSEA	20	15	25	23	16	13	8	2	8	18	16	13	**177**
KSHN	21	19	29	20	18	10	9	1	8	18	18	12	**183**
KYKM	8	3	15	2	9	5	4	0	2	8	5	4	**65**
* See Table 2-2 for Corresponding Met Station Names.													

Table 2-6. Monthly Precipitation in Inches, 2011													
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
KALW	1.38	1.18	3.35	2.10	4.23	1.60	0.23	0.08	0.03	1.37	1.05	1.25	**17.85**
KBLI	7.02	2.15	3.85	4.75	4.51	1.18	1.25	0.58	0.89	1.91	4.62	2.13	**34.84**
KCLM	1.56	2.32	2.46	1.44	0.25	0.01	0.26	0.02	0.48	0.98	4.65	0.93	**15.36**
KDLS	1.34	0.12	2.37	1.57	2.20	0.16	0.48	0.00	0.02	0.97	1.31	2.21	**12.75**
KEAT	0.60	0.08	2.02	0.03	1.84	0.32	0.49	0.00	0.00	0.66	0.29	0.22	**6.55**
KELN	1.34	0.44	2.94	0.35	2.94	0.31	0.53	0.00	0.03	0.66	0.65	0.72	**10.91**
KFHR	4.34	1.89	2.84	2.45	2.78	0.57	0.59	0.35	0.62	1.75	3.84	1.45	**23.47**
KGEG	2.44	1.17	3.37	1.77	1.88	0.62	0.53	0.00	0.37	0.77	1.72	1.01	**15.65**
KHQM	11.28	7.12	12.98	7.37	4.31	1.53	1.84	0.35	2.50	6.52	9.39	4.13	**69.32**
KKLS	4.37	3.53	6.25	4.26	2.84	1.08	1.29	0.00	0.91	1.85	3.50	2.14	**32.02**
KLWS	1.10	1.88	1.91	1.61	3.54	0.68	0.15	0.05	0.14	1.00	0.99	0.21	**13.26**
KMWH	0.74	0.03	0.99	0.51	1.53	0.63	0.11	0.00	0.07	0.35	0.15	0.23	**5.34**
KOLM	7.32	4.14	9.17	4.25	4.06	0.90	1.45	0.32	1.66	3.46	8.20	4.70	**49.63**
KOMK	0.62	0.35	2.73	0.23	2.48	1.17	0.90	0.00	0.07	0.97	0.63	0.53	**10.68**
KPAE	3.95	2.60	6.56	4.26	3.41	1.42	1.34	0.04	0.29	2.02	6.34	1.09	**33.32**
KPDX	4.78	2.84	7.94	5.15	2.99	0.83	0.99	0.22	0.68	2.14	6.65	2.57	**37.78**
KPSC	0.63	0.33	1.22	0.53	1.39	1.26	0.19	0.03	0.03	0.59	0.17	0.13	**6.50**
KPUW	2.43	1.40	3.70	2.59	2.84	0.67	0.03	0.00	0.23	1.48	1.65	1.46	**18.48**
KPWT	4.05	3.62	11.35	4.83	3.70	0.82	0.93	0.00	2.71	2.76	7.57	3.52	**45.86**
KSEA	4.99	2.90	6.40	4.70	3.12	1.64	0.71	0.13	1.30	3.46	5.22	2.24	**36.81**
KSHN	3.90	5.42	12.20	7.24	4.21	0.52	1.58	0.65	3.89	5.25	11.15	6.54	**62.55**
KYKM	0.67	0.09	1.44	0.32	2.30	0.50	0.46	0.00	0.07	0.90	0.51	0.38	**7.64**
* See Table 2-2 for Corresponding Met Station Names.													

Table 2-7. Monthly Heating Degree Days													
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
KALW	818	717	538	495	250	53	2	0	20	301	619	953	**4,763**
KBLI	743	732	585	566	374	163	76	44	108	431	670	780	**5,273**
KCLM	783	773	715	654	471	301	193	141	168	481	689	815	**6,183**
KDLS	757	691	604	447	213	36	0	0	21	253	630	888	**4,540**
KEAT	1,076	890	716	551	261	59	1	0	47	392	840	1,073	**5,906**
KELN	1,038	835	716	600	311	102	12	5	73	401	818	1,069	**5,981**
KFHR	729	718	584	580	408	226	170	136	150	449	660	728	**5,538**
KGEG	1,085	986	796	679	375	178	33	4	93	498	860	1,095	**6,682**
KHQM	684	681	613	590	437	234	168	126	139	377	622	744	**5,414**
KKLS	714	695	587	523	350	166	46	20	59	338	617	790	**4,906**
KLWS	862	818	622	543	289	77	2	0	21	342	707	953	**5,236**
KMWH	1,091	881	663	558	283	59	7	1	57	412	856	1,116	**5,983**
KOLM	751	770	674	625	445	226	94	79	125	425	729	852	**5,793**

Table 2-7. Monthly Heating Degree Days													
Call*	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
KOMK	1,162	987	723	598	299	110	14	0	87	517	945	1,126	**6,568**
KPAE	725	715	610	585	396	205	106	53	74	386	647	768	**5,269**
KPDX	702	675	589	498	321	96	9	2	23	268	585	783	**4,549**
KPSC	857	738	577	465	223	29	6	0	43	319	727	1,010	**4,994**
KPUW	1,012	966	759	692	427	221	80	24	97	481	801	1,022	**6,581**
KPWT	792	801	693	698	412	240	116	85	119	500	764	846	**6,065**
KSEA	711	699	609	573	370	160	27	21	71	376	647	798	**5,062**
KSHN	766	759	674	630	426	224	83	59	102	458	738	830	**5,750**
KYKM	963	831	697	581	311	99	19	0	73	423	825	1,067	**5,890**
***** See Table 2-2 for Corresponding Met Station Names.													

3 Base Year 2011 Emissions Estimates

To estimate emissions, four basic tasks were completed for each source category. The four tasks were: 1) estimate the activity level, 2) adjust/allocate the activity level (or emissions) temporally and spatially, 3) determine emission rates per the activity, and 4) estimate emissions. The tasks are described below for each source category. Emissions estimates may be found in Section 4.

3.1 Point Sources

Industrial, commercial, or institutional stationary sources which emit criteria and/or hazardous air pollutants are called point sources. Major point sources are those with the potential to emit 100 tons per year or more of any one criteria pollutant or a combination of criteria pollutants, and/or point sources with the potential to emit 10 tons per year or more of any single Hazardous Air Pollutant, or 25 tons per year or more of a combination of Hazardous Air Pollutants (Section 112, CAA). Facilities with a major source potential-to-emit are included in Title V Air Operating Permit (AOP) programs unless a facility voluntarily adopts federally enforceable permit limits that reduce their potential-to-emit below the criteria and HAPs thresholds. Facilities that adopt these limits are called Synthetic Minor sources.

Local air agencies, Ecology regional offices, and Ecology's Industrial Section and Nuclear Waste Program (regulating authorities) collect emissions data for facilities in their jurisdictions according to state and local regulations and air operating permit programs. After data collection, regulating authorities make any necessary calculations and perform quality assurance. When the inventories are complete, they enter the data into Ecology's Washington Emissions Inventory Repository Database (WEIRD).

All Title V sources (major) are included in the point source inventory. Synthetic Minor sources are included at the discretion of the regulating authority.

The inventories provided by the local air agencies are considered the official record for Washington State point sources. Ecology will submit the data to EPA in accordance with federal reporting requirements without significant change. For internal use, the data was enhanced in the

following ways: (1) annual emissions were seasonally allocated (Section 3.1.2), (2) missing PM_{10} and/or $PM_{2.5}$ estimates were added (Section 3.1.3), and (3) missing geographic coordinates were added.

3.1.1 Activity Level

Individual facility throughputs and production rates determine the activity level for each facility.

3.1.2 Spatial and Temporal Allocation

Point sources are located by county, address, and coordinates. Point sources are requested to provide quarterly throughput percentages. When provided, these schedules were used to allocate emissions to the seasons. When not provided, throughput and resulting emissions were assumed uniform throughout the year and 25% of the annual total was assigned to each season.

3.1.3 Emission Rates and Estimates

Emissions estimates for each facility are calculated using a variety of emissions estimation methods: continuous emissions monitors, stack test data, mass balance, best professional judgment, manufacturer's specifications, speciation profiles, EPA emission factors (e.g., AP-42), and/or other state, manufacturer, or research group emission factors. Methods are selected considering permit conditions, data availability, and resource constraints.

For Ecology use, if PM_{10} emissions estimates were missing, it was assumed that PM_{10} = reported total particulate. If $PM_{2.5}$ emissions estimates were missing, it was assumed that $PM_{2.5} = PM_{10}$.

3.2 Onroad Mobile Sources

Onroad mobile source emissions are those generated by operating vehicles on public roadways. Emissions from fuel combustion and evaporation, and brake and tire wear were estimated.

EPA's Motor Vehicle Emission Simulator (MOVES) model version 2010b was to calculate emissions. MOVES combines basic vehicle activity information with information about vehicle and fuel characteristics, emissions control programs, meteorological information, and other parameters to estimate emissions. The basic activity data are vehicle miles traveled (VMT) and vehicle population.

VMT, vehicle population, and a brief description of the MOVES input parameters are described below. The MOVES Technical Guidance for SIP inventories and the MOVES User's Guide were used in developing many of the inputs to MOVES.[3, 4]

3.2.1 Vehicle Miles Traveled (VMT)

VMT are used in MOVES to calculate emissions while the vehicle is in motion or during short periods of idling. The source of county VMT data used in this inventory was the Washington State Department of Transportation (WSDOT) under the national Department of Transportation's Highway Performance Monitoring System (HPMS).[5] HPMS is a system of traffic counts collected over several urban and rural sampling areas. WSDOT makes estimates of county VMT by roadway (functional) classification using the HPMS data.

Table 3-1. Average Daily Vehicle Miles Traveled in Thousands by HPMS Road Type, 2011											
	Rural					Urban					
County	Int	PA Art	MA	Coll	Loc	Int	PA	MA	Coll	Loc	Total
Adams	572	451	0	185	91	0	9	27	3	5	1,343
Asotin	0	21	15	28	5	0	48	89	30	21	257
Benton	911	1	232	290	108	197	1161	584	236	269	3,989
Chelan	0	592	194	295	81	0	246	163	36	55	1,662
Clallam	0	552	24	465	78	0	156	56	86	37	1,454
Clark	621	59	93	435	92	1,747	2,459	1,025	463	704	7,698
Columbia	0	81	0	56	10	0	0	0	0	0	147
Cowlitz	1,431	44	185	186	137	401	391	271	122	147	3,315
Douglas	0	312	49	117	36	0	260	55	48	45	922
Ferry	0	30	48	150	17	0	0	0	0	0	245
Franklin	0	465	0	289	57	365	327	145	64	112	1,824
Garfield	0	84	0	58	11	0	0	0	0	0	153
Grant	593	322	468	566	147	79	278	115	44	64	2,676
Grays	0	658	213	391	95	0	306	97	61	57	1,878
Island	0	435	0	376	61	0	75	195	22	36	1,200
Jefferson	0	403	115	188	53	0	62	0	65	16	902
King	1,243	384	965	1042	273	12,889	13,688	7,201	3,135	4,564	45,384
Kitsap	0	573	79	429	81	0	2,071	805	252	387	4,677
Kittitas	2,127	158	2	279	193	84	66	54	33	29	3,025
Klickitat	0	273	13	285	43	0	0	0	0	0	614
Lewis	628	340	192	343	113	887	118	160	53	150	2,984
Lincoln	268	175	78	161	51	0	0	0	0	0	733
Mason	0	603	43	433	81	0	93	11	32	17	1,313
Okanogan	0	370	400	350	84	0	0	0	0	0	1,204
Pacific	0	186	161	195	41	0	0	0	0	0	583
Pend Oreille	0	99	108	79	21	0	0	0	0	0	307
Pierce	339	0	649	251	93	3,232	6,668	3,332	1,134	1776	17,474
San Juan	0	0	0	134	10	0	0	0	0	0	144
Skagit	838	179	230	587	138	431	504	471	158	193	3,729
Skamania	0	162	0	153	24	0	0	0	0	0	339
Snohomish	691	330	221	727	148	4,672	3,828	2,068	1,206	1,456	15,347
Spokane	297	608	189	879	149	1,810	3066	1,424	436	833	9,691
Stevens	0	394	102	353	64	0	0	0	0	0	913
Thurston	755	336	292	688	156	1,595	1015	894	191	457	6,379
Wahkiakum	0	67	0	30	7	0	0	0	0	0	104
Walla Walla	0	359	112	180	49	0	267	165	53	60	1,245
Whatcom	464	230	177	1005	141	910	298	606	192	248	4,271
Whitman	0	473	1	285	57	0	101	52	26	22	1,017
Yakima	752	234	217	931	161	489	978	673	197	289	4,921
State Total	12,530	11,043	5,867	13,874	3,257	29,788	38,539	20,738	8,378	12,049	156,063
Abbreviations: Interstate = Int, Principal Arterial = PA, Minor Arterial = MA, Collector = Coll, Local = Loc											

3.2.2 Vehicle Population

Vehicle population is used to calculate emissions while a vehicle is stationary. The emissions come from engine starts, extended idling, and some fuel evaporation processes. Vehicles are classified by age and type. There are thirteen vehicle types in MOVES within six broader categories: cars, motorcycles, light-duty trucks, heavy-duty single unit trucks, heavy-duty combination unit trucks, and buses.

Three sources were used to calculate vehicle population. The first was the Washington State Department of Licensing (DOL). DOL registers non-governmental vehicles annually.[6] Because DOL does not register public transit and school buses each year, alternate sources of information were obtained. Transit and Intercity bus data came from the Federal Transit Administration (FTA) Annual Report data for 2010 (most recent available).[7] School bus information was obtained from the Washington State Office of the Superintendent of Public Instruction (OSPI).[8]

Table 3-2. Vehicle Population, 2011

County	Motor-cycle	Cars	Light Trucks	Buses	Single Unit Trucks	Combi-nation Unit Trucks	Total
Adams	328	6,427	9,971	79	275	99	17,179
Asotin	827	7,204	10,720	42	443	113	19,349
Benton	6,853	65,567	85,539	454	3,300	928	162,641
Chelan	3,838	25,549	41,693	197	1,452	379	73,108
Clallam	2,773	25,779	40,400	124	2,072	373	71,521
Clark	11,967	148,478	172,491	863	6,082	2,229	342,110
Columbia	148	1,420	2,642	18	96	21	4,345
Cowlitz	3,301	37,328	53,155	258	2,120	536	96,698
Douglas	1,753	12,234	19,616	82	808	203	34,696
Ferry	228	2,377	5,113	46	181	39	7,984
Franklin	1,689	26,789	36,911	176	1,172	420	67,157
Garfield	44	750	1,555	10	49	11	2,419
Grant	2,671	30,190	48,220	241	1,798	470	83,590
Grays Harbor	2,063	25,772	37,091	158	1,581	379	67,044
Island	3,997	31,713	42,996	94	1,785	411	80,996
Jefferson	1,416	13,384	17,610	53	1,003	157	33,623
King	48,426	731,125	713,617	3,671	20,782	10,118	1,527,739
Kitsap	10,377	94,478	117,238	543	4,686	1,323	228,645
Kittitas	1,972	13,254	23,629	75	1,044	215	40,189
Klickitat	799	7,856	13,081	91	494	107	22,428
Lewis	2,671	28,865	44,134	190	1,782	396	78,038
Lincoln	301	3,798	7,750	102	287	55	12,293
Mason	2,556	23,463	35,625	132	1,687	318	63,781
Okanogan	1,503	13,654	26,446	134	862	214	42,813

Table 3-2. Vehicle Population, 2011							
County	**Motor-cycle**	**Cars**	**Light Trucks**	**Buses**	**Single Unit Trucks**	**Combi-nation Unit Trucks**	**Total**
Pacific	590	7,908	13,216	84	592	109	22,499
Pend Oreille	520	5,066	9,124	47	402	67	15,226
Pierce	24,434	269,759	333,635	1,660	11,973	4,178	645,639
San Juan	868	6,697	10,879	17	327	82	18,870
Skagit	4,690	46,451	62,922	284	2,684	610	117,641
Skamania	521	4,617	6,695	27	242	58	12,160
Snohomish	23,656	257,332	300,607	1,366	10,572	3,734	597,267
Spokane	15,413	151,503	204,024	919	7,525	2,461	381,845
Stevens	1,566	17,116	29,800	157	1,162	227	50,028
Thurston	9,140	102,662	119,212	577	4,659	1,323	237,573
Wahkiakum	137	1,484	2,687	14	91	21	4,434
Walla Walla	2,076	18,777	27,132	109	1,041	307	49,442
Whatcom	7,317	75,380	90,728	423	3,753	1,052	178,653
Whitman	928	12,070	16,259	144	584	233	30,218
Yakima	5,516	84,934	118,307	465	4,371	1,275	214,868
Total	**209,873**	**2,439,210**	**2,952,470**	**14,126**	**105,819**	**35,251**	**5,756,749**

3.2.3 MOVES Input Parameters

MOVES includes a default database that summarizes emission relevant information for all counties in the United States. Default data may be replaced by local data to improve the estimates. Ecology developed local data for many of the parameters in MOVES.

Input parameters were developed that were characteristic of local conditions for each county and month. Some of the parameters presented here required local data. For others, EPA guidance recommended that local data be used. The parameters are shown in the table below.

Table 3-3. MOVES Model Parameters		
Parameter	**Data Source**	**References**
Vehicle population	DOL, OSPI, FTA	6, 7, 8
VMT	WSDOT with EPA default tailoring	5, 9
Temporal allocation to month, day of week, and hour	WSDOT with EPA default tailoring	10
Vehicle Inspection and Maintenance (I/M) Program (aka Vehicle Check Program)*	Dept. of Ecology I/M program records	11, 12, 13
California Emissions Standards	CA standards are incorporated into the MOVES model as an option	14
Fuel parameters	Local fuel surveys, state regulations and EPA default data	15, 16, 17, 18, 19, 20
Hourly temperatures	Local airport meteorology	21
Road type distribution	WSDOT with EPA default tailoring	5, 9
Vehicle age distribution	Local (DOL, OSPI, FTA)	6, 7, 8
Speeds	Default	
Ramp fraction	Default	
Vehicle refueling	Dept. of Ecology and Default	22, 23, 24, 25
* The vehicle Inspection and Maintenance (I/M) program is operated in Clark, King, Pierce, Snohomish, and Spokane Counties.		

3.3 Paved Road Dust

Dust emissions are generated as vehicles pass along paved roadways and disturb the layer of loose material on or near the road surface. This material contains particulate matter from soil, brake and tire wear, exhaust, and other substances. However, the paved road dust calculation excludes emissions from exhaust and brake and tire wear, which are estimated as part of the onroad mobile sources emissions (see Section 3.2).

3.3.1 Activity Level, Temporal and Spatial Allocation

The measures of activity and temporal and spatial allocation for paved road dust emissions calculations are identical to those used in the onroad mobile source category (Section 3.2). The monthly adjustment factors for VMT were not shown in the onroad section, but are presented here:

Table 3-4. WSDOT VMT Monthly Adjustment Factors												
WSDOT Road Type	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Rural interstate	0.77	0.85	0.93	1.00	1.03	1.12	1.22	1.24	1.10	1.03	0.89	0.83
Other rural arterial	0.77	0.86	0.90	0.95	1.04	1.12	1.25	1.26	1.11	1.03	0.84	0.79
Other rural	0.72	0.77	0.82	0.87	1.05	1.23	1.42	1.36	1.20	1.01	0.84	0.71
Urban interstate	0.92	0.97	0.99	1.01	1.06	0.99	0.98	0.98	0.99	0.95	0.91	0.91
Other urban arterial	0.92	0.95	0.98	1.01	1.06	1.07	1.06	1.07	1.03	1.00	0.93	0.93

The HPMS Average Daily VMT (ADVMT) estimate includes travel over both paved and unpaved roads; however, they are not distinguished from one another. A slight overestimation of ADVMT does occur when using HPMS ADVMT as the paved road activity level. The overestimation is not significant, though, since unpaved ADVMT is only estimated to be 0.5% of the entire ADVMT (see Section 3.4).

3.3.2 Emission Rates

The PM_{10} and $PM_{2.5}$ emission rates in grams per mile were calculated using equation 2 in EPA's AP42.[26, 27] Equation 2 estimates an emission rate for annual average conditions by incorporating a precipitation correction factor. This equation was used to calculate monthly emission rates. The AP42 equation is shown below.

$$E = [k\ (sL)^{0.91}\ (W)^{1.02}]\ \times\ [1-(P/4N)] \quad \text{equation (2)}$$

where E is the emission factor in g/VMT
k = g/VMT particle size multiplier (1 for PM_{10}, 0.25 for $PM_{2.5}$)
sL = silt loading in g/m^2
W = mean vehicle weight (tons)
P = number of days with at least 0.01 inches of precipitation in the given month
N = number of days in the given month

AP42 provides recommended values of average and worst-case silt loading on roads for several average daily traffic (ADT) classes. For this inventory, the average silt loading values were used. The HPMS facility types were assigned to ADT classes based on the number of ADVMT per roadway miles. These classifications are shown in Table 3-5. Individual urban sampling areas are not shown in the table; though, with the exceptions of the smallest urban areas, they all showed the same ADT classification as their urban average.

Mean vehicle weight by road class was calculated from the FHWA report of in-use operating weights and VMT by vehicle type and road class.[28]
Days per month of precipitation greater than 0.01 inches in 2011 were obtained (see Section 2.2). County assignments were made as shown in Table 2-2.

Dry day PM_{10} emission rates calculated with Equation 2 ranged from 0.057 to 1.681 g/mi while $PM_{2.5}$ emission rates ranged from 0.014 to 0.420 g/mi.

Table 3-5. Estimated Average Daily Traffic							
Rural	**Interstate**	**Free/Expr**	**Prin Art**	**Min Art**	**Maj Coll**	**Min Coll**	**Local**
Miles	467	645	1,335	1,910	8,432	6,453	40,817
ADVMT (in 1,000s)	12,531	4,873	6,172	5,867	10,690	3,185	3,260
Estimated ADT	26,815	7,551	4,623	3,072	1,268	494	80
ADT Class	> 10,000 limited access	5,000-10,000	500-5,000	500-5,000	500-5,000	< 500	< 500
silt loading (g/m^2)	0.015	0.06	0.2	0.2	0.2	0.6	0.6
Urban	**Interstate**	**Free/Expr**	**Prin Art**	**Min Art**	**Maj Coll**	**Min Coll**	**Local**
Miles	297	377	1,355	2,684	2,431	0	16,540
ADVMT (in 1,000s)	29,788	14,416	24,122	20,737	8,376	0	12,051
Estimated ADT	100,320	38,273	17,804	7,727	3,446	0	729
ADT Class	> 10,000 limited access	5,000-10,000	500-5,000	500-5,000	500-5,000	< 500	< 500
silt loading (g/m^2)	0.015	0.015	0.03	0.06	0.2	0.2	0.2

Table 3-6. Mean Vehicle Weight in Tons							
Rural/Urban	**Interstate**	**Free/Expr**	**Prin Art**	**Min Art**	**Maj Coll**	**Min Coll**	**Local**
Rural	5.71	5.71	3.80	3.16	2.74	2.62	2.49
Urban	3.27	2.56	2.51	2.26	2.18	2.18	2.14

3.3.3 Emissions Estimates

Monthly emissions were calculated using the equations below. Seasonal and annual emissions were calculated by summing the appropriate months (see Section 1.4).

V x M x D x E x (lb/454 g) x (1 T/2000 lb) - monthly emissions

where V = ADVMT

M = monthly VMT adjustment factor (Table 3-4)

D = number of days in month, and

E = emission factor in g/VMT, calculated as described in Section 3.3.2

3.4 Unpaved Road Dust

Similar to paved roads, dust emissions are generated as vehicles pass along unpaved roadways and disturb the layer of loose material on or near the road surface. This material contains particulate matter from soil, brake and tire wear, exhaust, and other substances. The unpaved road dust calculation excludes emissions from exhaust and brake and tire wear, which are estimated as part of the onroad mobile sources emissions (see Section 3.2).

3.4.1 Activity Level

Similar to onroad mobile sources and paved road dust, ADVMT is used to estimate unpaved road activity and calculate dust emissions. Travel over unpaved roads is included in HPMS ADVMT estimates, but are not separated from the paved road travel. Two agencies were contacted to obtain ADVMT on unpaved roads. The County Road Administration Board (CRAB) provided roadway mileage and ADVMT estimates on unpaved road by county.[29] WSDOT provided estimates of city jurisdiction unpaved roadway mileage for each county.[30] The CRAB data was used to develop an average daily traffic (ADT) per centerlane-mile factor (53 ADT/mi). This factor was multiplied by the WSDOT city centerlane-mileage data in order to estimate ADVMT. Unpaved roads on federal, state, and tribal lands are missing from this inventory.

The total county and city jurisdictions ADVMT are shown in the table below. ADVMT over unpaved roads was included in the HPMS data, so it is essentially being double counted within paved road estimates. The overestimation is not significant, though, since unpaved ADVMT is only estimated to be 0.5% of the entire ADVMT.

Table 3-7. ADVMT on Unpaved Roads – Total of County and City Jurisdictions

County	ADVMT		County	ADVMT
Adams	38,436		Lewis	2,924
Asotin	6,970		Lincoln	48,525
Benton	6,610		Mason	4,349
Chelan	7,329		Okanogan	33,062
Clallam	808		Pacific	4,108
Clark	1,157		Pend Oreille	20,807
Columbia	15,611		Pierce	7,444
Cowlitz	353		San Juan	2,945
Douglas	74,366		Skagit	2,856
Ferry	19,341		Skamania	1,188
Franklin	20,600		Snohomish	1,776
Garfield	17,932		Spokane	116,547
Grant	71,264		Stevens	45,897
Grays Harbor	7,195		Thurston	3,066
Island	192		Wahkiakum	1,822
Jefferson	4,872		Walla Walla	14,116
King	62,295		Whatcom	5,118
Kitsap	4,970		Whitman	53,604
Kittitas	4,965		Yakima	57,818
Klickitat	17,545		**State Total**	**810,783**

3.4.2 Temporal and Spatial Allocation

Spatial adjustments were not necessary since the ADVMT was available by county. Monthly temporal adjustments for the arterial/local roadway type were made using the WSDOT temporal adjustment factors for urban roads shown in Table 3-4.

3.4.3 Emission Rates

Unpaved road dust emissions were estimated according to Equation 2 in AP42.[31] The equation includes an adjustment for rainfall which acts as a control efficiency term by assuming that emissions occur only on days where the rainfall is below 0.01 inches. The equation was modified to calculate monthly emission rates. The original and modified AP42 equations are shown below.

$E = [k\ (s/12)^a\ (S/30)^d\ /\ (M_{dry}/0.5)^c - C] \times [(365-p)/365]$ (original AP42 Equation 2)

$E = \{[k\ (s/12)^a\ (S/30)^d\ /\ (M_{dry}/0.5)^c] - C\} \times [(n-p)/n]$ (modified AP42 Equation 2)

where E is the emission factor in lb/VMT

k = particle size multiplier (1.8 for PM_{10}, 0.18 for $PM_{2.5}$)

a = PM_{10} constant (1)

c = PM_{10} constant (0.2)

d = PM_{10} constant (0.5)

S = speed in mph

C = material from exhaust, brake and tire wear in lb/mi (AP42 default: 0.00047 for PM_{10}, 0.00036 for $PM_{2.5}$)

n = number of days in the given month

p = number of days with at least 0.01 inches of precipitation in the given month

M_{dry} = surface material moisture content (%)

Monthly days of precipitation greater than 0.01 inches were taken from Table 2-5. Vehicle speed was not available. The VMT-weighted average speed on local roads for Spokane in 2002 was used as an estimate (30 mph).[32]

The surface material silt content (3.2%) and moisture content (1%) were obtained from the Western Regional Air Partnership (WRAP).[33, 34] Silt values used by EPA in the 1999 NEI were derived from sampling data taken from a database of approximately 200 samples from 30 states.[35] Washington was not sampled. EPA used the national average of 3.9% for all states not sampled when they prepared the 1999 NEI. Rather than using the national average for states that were not sampled, the WRAP calculated an average of 3.2% for western states using the silt content database.[33] The WRAP value was used in this inventory.
Calculated monthly emission rates are shown in Table 3-8 and Table 3-9. County assignments were the same as described in Section 2.2.

Table 3-8. Unpaved Roads PM_{10} Emission Rates in lb/mi												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
KALW	0.242	0.313	0.094	0.237	0.229	0.292	0.377	0.377	0.390	0.269	0.237	0.350
KBLI	0.108	0.209	0.135	0.111	0.189	0.250	0.242	0.350	0.320	0.175	0.181	0.162
KCLM	0.175	0.224	0.189	0.237	0.310	0.403	0.364	0.404	0.348	0.350	0.250	0.296
KDLS	0.256	0.313	0.175	0.292	0.283	0.390	0.364	0.417	0.403	0.229	0.250	0.323
KEAT	0.350	0.373	0.215	0.403	0.296	0.362	0.364	0.417	0.417	0.310	0.306	0.377
KELN	0.202	0.239	0.148	0.362	0.269	0.348	0.377	0.417	0.390	0.269	0.264	0.310
KFHR	0.148	0.224	0.094	0.167	0.202	0.223	0.242	0.269	0.195	0.108	0.195	0.175
KGEG	0.202	0.283	0.121	0.167	0.202	0.306	0.323	0.417	0.362	0.229	0.264	0.296
KHQM	0.094	0.134	0.013	0.070	0.121	0.167	0.242	0.350	0.264	0.162	0.111	0.135
KKLS	0.215	0.179	0.121	0.167	0.215	0.237	0.283	0.417	0.334	0.256	0.237	0.323
KLWS	0.269	0.224	0.148	0.209	0.162	0.264	0.350	0.390	0.390	0.269	0.292	0.350
KMWH	0.283	0.388	0.242	0.348	0.269	0.334	0.390	0.417	0.390	0.337	0.348	0.377
KOLM	0.148	0.134	0.081	0.139	0.202	0.278	0.296	0.350	0.264	0.175	0.167	0.242
KOMK	0.337	0.343	0.175	0.362	0.215	0.320	0.323	0.417	0.390	0.337	0.278	0.350
KPAE	0.148	0.179	0.054	0.083	0.175	0.167	0.242	0.404	0.348	0.121	0.153	0.175
KPDX	0.162	0.104	0.027	0.028	0.094	0.237	0.269	0.377	0.264	0.189	0.125	0.229
KPSC	0.283	0.343	0.215	0.306	0.269	0.348	0.377	0.404	0.403	0.256	0.334	0.377
KPUW	0.229	0.179	0.108	0.181	0.175	0.250	0.377	0.417	0.362	0.256	0.223	0.323
KPWT	0.242	0.268	0.135	0.181	0.229	0.292	0.337	0.417	0.320	0.310	0.292	0.323
KSEA	0.148	0.194	0.081	0.097	0.202	0.237	0.310	0.390	0.306	0.175	0.195	0.242
KSHN	0.135	0.134	0.027	0.139	0.175	0.278	0.296	0.404	0.306	0.175	0.167	0.256
KYKM	0.310	0.373	0.215	0.390	0.296	0.348	0.364	0.417	0.390	0.310	0.348	0.364

Table 3-9. Unpaved Roads $PM_{2.5}$ Emission Rates in lb/mi												
Station	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
KALW	0.024	0.031	0.009	0.023	0.023	0.029	0.037	0.037	0.039	0.027	0.023	0.035
KBLI	0.011	0.021	0.013	0.011	0.019	0.025	0.024	0.035	0.032	0.017	0.018	0.016
KCLM	0.017	0.022	0.019	0.023	0.031	0.040	0.036	0.040	0.035	0.035	0.025	0.029
KDLS	0.025	0.031	0.017	0.029	0.028	0.039	0.036	0.041	0.040	0.023	0.025	0.032
KEAT	0.035	0.037	0.021	0.040	0.029	0.036	0.036	0.041	0.041	0.031	0.030	0.037
KELN	0.020	0.024	0.015	0.036	0.027	0.035	0.037	0.041	0.039	0.027	0.026	0.031
KFHR	0.015	0.022	0.009	0.017	0.020	0.022	0.024	0.027	0.019	0.011	0.019	0.017
KGEG	0.020	0.028	0.012	0.017	0.020	0.030	0.032	0.041	0.036	0.023	0.026	0.029
KHQM	0.009	0.013	0.001	0.007	0.012	0.017	0.024	0.035	0.026	0.016	0.011	0.013
KKLS	0.021	0.018	0.012	0.017	0.021	0.023	0.028	0.041	0.033	0.025	0.023	0.032
KLWS	0.027	0.022	0.015	0.021	0.016	0.026	0.035	0.039	0.039	0.027	0.029	0.035
KMWH	0.028	0.038	0.024	0.035	0.027	0.033	0.039	0.041	0.039	0.033	0.035	0.037
KOLM	0.015	0.013	0.008	0.014	0.020	0.028	0.029	0.035	0.026	0.017	0.017	0.024
KOMK	0.033	0.034	0.017	0.036	0.021	0.032	0.032	0.041	0.039	0.033	0.028	0.035
KPAE	0.015	0.018	0.005	0.008	0.017	0.017	0.024	0.040	0.035	0.012	0.015	0.017
KPDX	0.016	0.010	0.003	0.003	0.009	0.023	0.027	0.037	0.026	0.019	0.012	0.023
KPSC	0.028	0.034	0.021	0.030	0.027	0.035	0.037	0.040	0.040	0.025	0.033	0.037
KPUW	0.023	0.018	0.011	0.018	0.017	0.025	0.037	0.041	0.036	0.025	0.022	0.032
KPWT	0.024	0.027	0.013	0.018	0.023	0.029	0.033	0.041	0.032	0.031	0.029	0.032
KSEA	0.015	0.019	0.008	0.010	0.020	0.023	0.031	0.039	0.030	0.017	0.019	0.024
KSHN	0.013	0.013	0.003	0.014	0.017	0.028	0.029	0.040	0.030	0.017	0.017	0.025
KYKM	0.031	0.037	0.021	0.039	0.029	0.035	0.036	0.041	0.039	0.031	0.035	0.036

3.4.4 Emissions Estimates

Monthly emissions were calculated using the equation below. Seasonal and annual emissions were calculated by summing the appropriate months (see Section 1.4).

Monthly Emissions (Tons) = V x M x D x E x (1 T/2000 lb)
where V = ADVMT
M = monthly VMT adjustment factor (Table 3-4)
D = number of days in month, and
E = emission factor in lb/VMT, calculated as described in Section 3.4.3

3.5 NONROAD Mobile Sources, Excluding Ships, Seaports, Locomotives and Aircraft

The Nonroad Mobile category includes emissions estimates from gasoline, diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG) fueled equipment. Emissions were estimated using EPA's NONROAD2008a model.[36] Equipment types are compiled into 11 categories:

Agricultural Equipment
Airport Service Equipment
Recreational Marine Vessels
Construction and Mining Equipment
Commercial Equipment
Industrial Equipment
Lawn and Garden Equipment
Logging Equipment
Oil Field Equipment
Recreational Equipment
Railroad Maintenance Equipment

3.5.1 Activity Level and Spatial Allocation

The NONROAD model contains data on statewide equipment types and usage. NONROAD utilizes spatial surrogates appropriate for each equipment type to disaggregate state activity levels to individual counties. The default surrogates were used for all equipment types except recreational marine vessels. The default spatial surrogate for recreational marine vessels is water surface area. This method can overestimate recreational boat usage in certain counties due to the large areas of open water in a county's jurisdiction. A new allocation based on county boat registrations was substituted for the default. Registrations for 2011 were provided by the Washington Department of Licensing (Table 3-10).[37]

Table 3-10. County Boat Registrations, 2011

County	Registrations		County	Registrations
Adams	692		Lewis	2673
Asotin	1139		Lincoln	1107
Benton	9304		Mason	4745
Chelan	5237		Okanogan	1897
Clallam	4109		Pacific	1140
Clark	13867		Pend Oreille	1206
Columbia	294		Pierce	25359

Table 3-10. County Boat Registrations, 2011				
County	**Registrations**		**County**	**Registrations**
Cowlitz	5206		San Juan	2298
Douglas	1973		Skagit	8452
Ferry	341		Skamania	340
Franklin	2908		Snohomish	24827
Garfield	112		Spokane	16261
Grant	5508		Stevens	2305
Grays Harbor	2888		Thurston	8682
Island	5518		Wahkiakum	411
Jefferson	2568		Walla Walla	1212
King	56086		Whatcom	7765
Kitsap	10595		Whitman	1004
Kittitas	1515		Yakima	5497
Klickitat	706		**State Total**	**247747**

3.5.2 Temporal Allocation and Emission Rates

Emissions were generated for the four seasons using the seasonal temporal option in the NONROAD2008a model. NONROAD2008a requires user input of seasonal meteorological and fuel parameters. The required fuel parameters are gasoline RVP and oxygen content; sulfur contents of gasoline, diesel (land and marine), and compressed natural gas (CNG) and liquefied petroleum gas (LPG); and presence of stage II vapor recovery requirements. Each is described briefly below.

Fuel Sulfur Content: EPA provided diesel sulfur contents with NONROAD2008a (file sulfur.txt). The values were 32 ppm and 236 ppm for land and marine diesel, respectively. Gasoline sulfur content was assumed to be the same as onroad sulfur content (30 ppm). CNG/LPG was assumed to contain 30 ppm sulfur (model template default).

Gasoline Oxygen Content: Most gasoline in Washington contains 10% ethanol. The corresponding oxygen content is 3.5%.

Gasoline Reid Vapor Pressure: RVP values for January, April, July, and October were used to model each of the four seasons. The values were the same as those for onroad.[15, 16]

Stage II Gasoline Vapor Recovery: Stage II refueling benefits were not modeled in NONROAD. There are stage II requirements on some gasoline stations, but there is no reliable method to estimate the fraction of equipment fueled via stage II stations. Furthermore, stage II benefits are small compared to the total nonroad inventory. For these reasons, no stage II requirements were modeled in NONROAD.

Meteorological Parameters: NONROAD requires minimum, maximum, and average temperature inputs in °F (Section 2.2). Temperatures for January, April, July, and October were

used to model each of the four seasons. Onroad mobile guidance was used to calculate average temperatures: minT + [2/3 * (maxT – minT)]. This equation may result in a temperature that is close to the average daytime temperature when most equipment is used.

Counties with similar parameters were grouped together. County assignments and parameters values are shown in the tables below.

Table 3-11. NONROAD Model Parameter Group County Assignments

Group	County Assignments
WWA	Clallam, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, Whatcom
Clark Co.	Clark
EWA Spokane	Chelan, Douglas, Ferry, Kittitas, Lincoln, Okanogan, Pend Oreille, Spokane, Stevens
EWA Yakima	Adams, Asotin, Benton, Columbia, Franklin, Garfield, Grant, Klickitat, Walla Walla, Whitman, Yakima

Table 3-12. NONROAD Model Parameter Values by Group

Group	Temperature (F)			RVP (psi)	Fuel Sulfur (%)				Fuel O2 (%)
	Min	Max	Avg		Gas	Land Diesel	Marine Diesel	CNG	
Winter									
WWA	34	47	43	14.7	0.003	0.0032	0.0236		3.5
Clark Co	34	47	43	14.7	0.003	0.0032	0.0236		3.5
EWA Spokane	22	38	32	14.2	0.003	0.0032	0.0236		3.5
EWA Yakima	21	45	37	14.2	0.003	0.0032	0.0236		3.5
Spring									
WWA	40	56	51	12.7	0.003	0.0032	0.0236		3.5
Clark Co	40	56	51	12.1	0.003	0.0032	0.0236		3.5
EWA Spokane	35	55	48	12.4	0.003	0.0032	0.0236		3.5
EWA Yakima	33	63	53	12.4	0.003	0.0032	0.0236		3.5
Summer									
WWA	53	74	67	10	0.003	0.0032	0.0236		3.5
Clark Co	53	74	67	8.8	0.003	0.0032	0.0236		3.5
EWA Spokane	52	81	71	10	0.003	0.0032	0.0236		3.5
EWA Yakima	49	87	74	10	0.003	0.0032	0.0236		3.5
Fall									
WWA	45	62	56	10	0.003	0.0032	0.0236		3.5
Clark Co	45	62	56	8.8	0.003	0.0032	0.0236		3.5
EWA Spokane	39	62	54	10	0.003	0.0032	0.0236		3.5
EWA Yakima	35	68	57	10	0.003	0.0032	0.0236		3.5

3.5.3 Emissions Estimates

Total seasonal emissions (tons per season) were generated with the NONROAD2008a model.

3.6 Locomotives

Emissions from Class I line-haul and switch yard locomotives were estimated using EPA guidance and other information.[38] U.S. Class I railroads are line-haul freight railroads with operating revenue in excess of $250 million or more after adjusting for inflation using the Railroad Freight Price Index ($433.2 million in 2011).[39, 40, 41] Class I railroads operate in Washington: Burlington Northern Santa Fe Railway (BNSF) and Union Pacific Railroad (UP). Amtrak was also included in this inventory. Class II and III railroad locomotive emissions were not inventoried. A special Northwest International Air Quality Environmental Science and Technology Consortium (NW-AIRQUEST; formerly Northwest Regional Technical Center) project conducted by the Oregon Department of Environmental Quality (ODEQ) found that emissions from Class 2 and 3 railroad locomotives were a small percentage of total locomotive emissions.[42, 43]

BNSF and UP provided 2011 activity and emissions information. Amtrak provided only activity information for 2011.

3.6.1 Activity Level

Activity level is measured in gallons of diesel consumed by locomotives. All of the railroads provided 2011 fuel use for line haul and switch yard locomotives by county.[44]

Table 3-13. Locomotive Fuel Consumption in Gallons

County	Line Haul	Yard	Passenger		County	Line Haul	Yard	Passenger
Adams	7,041,027	0	108,332		Lewis	2,593,182	100,000	216,664
Asotin	0	0	0		Lincoln	3,903,784	0	128,451
Benton	6,749,964	0	82,023		Mason	0	0	0
Chelan	2,057,112	50,000	89,761		Okanogan	0	0	0
Clallam	0	0	0		Pacific	0	0	0
Clark	4,127,375	550,000	184,164		Pend Oreille	0	0	0
Columbia	1,430	0	0		Pierce	3,112,695	319,151	170,236
Cowlitz	3,961,706	200,000	433,328		San Juan	0	0	0
Douglas	457,900	300,000	0		Skagit	648,107	0	77,380
Ferry	0	0	0		Skamania	4,121,850	0	77,380
Franklin	4,489,097	600,000	63,452		Snohomish	3,255,414	150,000	204,283
Garfield	0	0	0		Spokane	7,668,948	500,000	85,118
Grant	1,825,894	0	82,023		Stevens	104,586	0	0
Grays Harbor	3,090	0	0		Thurston	2,025,014	0	278,568
Island	0	0	0		Wahkiakum	0	0	0
Jefferson	0	0	0		Walla Walla	2,009,419	0	0

Table 3-13. Locomotive Fuel Consumption in Gallons								
County	Line Haul	Yard	Passenger		County	Line Haul	Yard	Passenger
King	4,251,346	1,112,251	334,282		Whatcom	963,185	100,000	108,332
Kitsap	0	0	0		Whitman	205,288	0	0
Kittitas	199,690	0	0		Yakima	407,696	50,000	0
Klickitat	9,464,213	0	136,189		State Total	75,649,012	4,031,402	2,859,966

3.6.2 Temporal and Spatial Adjustments

Most of the locomotive activity information was obtained by county; therefore, no spatial adjustments were necessary.

Locomotives were assumed to operate uniformly year-round per EPA guidance.[45]

3.6.3 Emission Rates

All railroad companies provided criteria pollutant emissions estimates by county, based on their locomotive fleet. Table 3-24 shows the emission factors used in each of their calculations.

The SO_2 emission rates were taken from earlier EPA guidance.[45] The $PM_{2.5}$ emission rates were assumed to be 92% of the PM_{10} per EPA correspondence with ODEQ.[43, 46]

Table 3-14. Locomotive Emission Factors in Grams per Gallon Fuel					
Pollutant	Code	Line-Haul UP	Line-Haul BNSF	Switch Yard	Passenger
Carbon Monoxide	CO	2.74E+01	2.6E+01	2.74E+01	2.66E+01
Nitrogen Oxides	NO_X	1.49E+02	1.49E+02	2.35E+02	1.67E+02
PM	PM	4.4E+00	4.4E+00	5.3E+00	4.5E+00
Sulfur Dioxide	SO_2	8.0E-01	8.0E-01	8.0E-01	1.8E+01
Volatile Organic Compounds	VOC	7.7E+00	7.7E+00	1.4E+01	8.1E+00

3.6.4 Emissions Estimates

For emissions calculated with speciation profiles, the equations used were:

tpy = (PM_{10} emissions in tpy) x (pollutant PM_{10} fraction)

tpy = (VOC emissions in tpy) x (pollutant VOC fraction)

3.7 Ships

Two separate annual emissions inventories were used to estimate emissions from ships: one for emissions occurring on the Columbia and Snake River systems, and one for Puget Sound, Strait of Juan de Fuca, and Coastal Waterways.

Columbia and Snake Rivers

EPA's 2011 NEI estimates were used for the Columbia and Snake Rivers. See Section 3.23.

Puget Sound, Strait of Juan de Fuca, and Coastal Waterways

For Puget Sound and Strait of Juan de Fuca, the 2011 inventory prepared for the Puget Sound Maritime Air Forum by Starcrest Consulting Group, LLC was used.[47] The inventory is a bottom-up, activity-based emissions inventory which provides detailed information on the five major source categories associated with the marine activities: ocean-going vessels, harbor vessels, cargo handling equipment, onroad heavy-duty vehicles, and rail operations. It was an update to a similar inventory prepared by Starcrest for the 2005 inventory.

The Starcrest emissions inventory was used for ocean-going vessels and harbor vessels (minus pleasure craft). It was also used for cargo handling equipment (see Section 3.8). The Starcrest inventory did not include comprehensive countywide estimates for pleasure craft, onroad heavy duty vehicles, or rail emissions. Comprehensive countywide estimates from these sources are addressed in Sections 3.5, 3.2 and 3.6, respectively.

3.7.1 Activity Level and Emission Rates

Activity level and emission rates of ships are described in the Starcrest report. The Starcrest report addressed PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO, and VOC. The Starcrest report did not provide toxics estimates.

3.7.2 Temporal and Spatial Allocation

Emissions from ships were assumed to be uniform year-round. The Starcrest report provides data by county but more detailed GIS data will be included with electronic information that will be provided in the future. The 2011 EPA NEI data is available by county.

3.7.3 Emissions Estimates

Emissions in tons per year were taken directly from the source data. For seasonal emissions the equation used was:

tps = (tpy) / (4 seasons)

3.8 Marine Cargo Handling Equipment

The Puget Sound and Strait of Juan de Fuca 2011 maritime inventory prepared by Starcrest and described in Section 3.7 included port and near-port emissions from cargo handling equipment. The ports included in the marine cargo handling equipment inventory were Anacortes, Everett, Seattle, Tacoma, and Olympia. The Argo and BNSF SIG rail yards were also included.

3.8.1 Activity Level and Emission Rates

Activity level and emission rates are described in the Starcrest inventory documentation, addressing PM_{10}, $PM_{2.5}$, NO_X, SO_2, CO, and VOC.[47]

3.8.2 Temporal and Spatial Allocation

Port emissions were assigned to their respective counties. Emissions were assumed to be uniform throughout the year.

3.8.3 Emissions Estimates

Emissions in tons per year were taken directly from the source data. For seasonal emissions the equation used was:

tps = (tpy) / (4 seasons)

There is potential for double-counting in this category since it overlaps with industrial equipment in the NONROAD model. However, in the NONROAD model the county allocations are based on manufacturing employment, which is not counted as port activity (Section 3.5). Therefore, emissions from the seaports were not subtracted from the NONROAD model output totals.

3.9 Silvicultural Burning (Prescribed Burning)

Silvicultural burning, also discussed as prescribed burning, includes logging debris burns and forest health burns. It does not include land clearing. Silvicultural burning is done by the Department of Natural Resources (DNR), U.S. Forest Service (USFS), Bureau of Indian Affairs (BIA), and private industry. DNR permits and tracks all burns, except those done by the BIA. Using models developed by the USFS, DNR estimates the tons burned and resulting air emissions.

The results from prescribed burning that DNR produced and those that EPA produced were very different. Therefore, the Washington emissions inventory data may look very different from the EPA data in this category. The BlueSky modeling framework was used to create the EPA data. This framework can lead to overestimates of prescribed burn emissions, especially in heavily forested regions (e.g. Clallam, Grays Harbor, Lewis, Pacific, and Skamania counties). Prescribed burns in Washington state are managed so that only a fraction of the fuels are burned; however, the BlueSky model does not take this fully into account and is configured to burn most available fuels within the simulations. There are also known over-estimates of duff consumption in BlueSky prescribed burn simulations.

3.9.1 Activity Level and Emission Rates

DNR enters information on each permitted burn into the USFS models. The required information includes: location, date, ownership, elevation, moisture, species, duff depth, tons of material and/or acres, burn type (broadcast, pile, natural). The USFS models calculate fuel consumption and emissions for each burn. The emission factors used in the model were developed for the Pacific Northwest by the USFS.

DNR provided the entire 2011 burn permit database, which was queried for activity level (in tons consumed) and emissions by county and season.[48] The database included PM, PM_{10}, and $PM_{2.5}$ estimates. Broadcast and natural burn particulate emission factors were calculated specifically for each fire. Pile burn particulate emissions were estimated using static emission factors. DNR estimated CO and non-methane hydrocarbons (used as VOC) for most broadcast and natural burns. NO_X emissions were estimated by Ecology using AP42.[49] VOC and CO emissions were estimated

for pile burns by Ecology using information from the USFS.[50] Table 3-15 shows the county activity level in tons consumed. Emission factors and references are shown in Table 3-16.

Table 3-15. Silvicultural Burning, Tons Burned, 2011

County	Tons		County	Tons
Adams	0		Lewis	13,060
Asotin	60		Lincoln	210
Benton	0		Mason	2,912
Chelan	23,652		Okanogan	16,452
Clallam	16,665		Pacific	9,040
Clark	2,347		Pend Oreille	27,603
Columbia	308		Pierce	183
Cowlitz	3,072		San Juan	3
Douglas	0		Skagit	5,620
Ferry	2,145		Skamania	1,696
Franklin	0		Snohomish	1,246
Garfield	80		Spokane	12,085
Grant	0		Stevens	7,628
Grays Harbor	17,356		Thurston	776
Island	9		Wahkiakum	637
Jefferson	7,189		Walla Walla	97
King	35		Whatcom	6,475
Kitsap	0		Whitman	0
Kittitas	4,499		Yakima	7,761
Klickitat	24,055		**State Total**	**214,956**

Table 3-16. Silvicultural Burning Emission Factors and References

Pollutant	Pile		Broadcast/Natural	
	EF	Reference	EF Range	Reference
PM	21.9	48	19.9 - 42.3	48
PM_{10}	15.5	48	12.6 - 31.3	48
$PM_{2.5}$	13.5	48	9.0 - 31.0	48
CO	76	50	67.1 - 243.3	48
NO_X	4	49	4	49
VOC	4.5	50	3.8 - 11.3	48

3.9.2 Temporal Adjustments

The date of each burn was included in the DNR burn permit database. Monthly emissions were calculated by summing the emissions for all burns occurring in each individual month.

3.9.3 Spatial Adjustments

No spatial adjustments were necessary. All burns were identified both by county, and section-township-range.

3.9.4 Emissions Estimates

As stated in Section 3.9.1, emissions were calculated for each burn by date. Seasonal emissions were calculated by summing all the burns occurring in the given season.

3.10 Agricultural Burning

Agricultural burning in Washington is defined as "the burning of vegetative debris from an agricultural operation necessary for disease or pest control, necessary for crop propagation and/or crop rotation, or where identified as a best management practice by the agricultural burning practices and research task force established in RCW [Revised Code of Washington] 70.94.650 or other authoritative source on agricultural practices." [51] All agricultural burning in Washington requires a permit. It is noted here that in Chelan, Douglas, Kittitas, Klickitat, and Okanogan Counties some orchards are removed but not replanted and thus do not qualify for agricultural burning permits. Emissions from these tear-outs are not included in the inventory due to lack of information.

3.10.1 Activity Level

The activity level for agricultural burning is the amount of residue burned (consumed). The general equation and sources of each parameter are described below.

tons burned = acres burned x fuel loading x fuel consumption factor

Acres or Tons Burned
Department of Ecology Central and Eastern Regional Offices (CRO, ERO)
The Department of Ecology maintains an agricultural burn permit database. The permits are tracked by location and date and include other information such as crop type, acreage, and fuel loading estimates, or tons burned.[52] Permits issued in 2011 were selected for this inventory.

Local Air Authority Permits
The agricultural burn permit database did not contain information for western Washington counties, or Benton, Spokane and Yakima Counties in eastern Washington. There is very little agricultural burning in western Washington and Spokane Counties. The Benton Clean Air Agency, Northwest Clean Air Agency, and Olympic Region Clean Air Agency provided acres burned or tons burned for agricultural burns permitted in their counties.

Fuel Loading
Department of Ecology Central and Eastern Regional Offices (CRO, ERO)
Department of Ecology Central and Eastern Regional Offices (CRO, ERO)

The agricultural burn permit database included a loading factor for each burn. The overall average loading factor for cereal grain stubble burns was 4.3 tons/acre. This is comparable to the 4 tons/acre average found in a special study performed by Air Sciences Incorporated.[53] Air Sciences Incorporated performed a field study funded by Ecology, the Washington Association of Wheat Growers, and the US EPA-Region 10 to measure emissions and develop emission rates for wheat stubble field burning. The loading factor was 0.8 tons/acre higher than the wheat field loading factor of 3.2 tons/acre in AP42 (adjusted for fuel consumption).

Local Air Authority Permits

Fuel loading factors for burns reported in acres for apple and other orchard trees, Christmas trees, daffodils, nursery stock, and limbs/weeds/blackberries were estimated from the Ecology burn permit database records (1-2-2009 through 3-26-2012) by calculating the average loading for these crop types. The unspecified weed loading in AP42[54] was used to estimate loading for potatoes and berries.

Fuel Consumption Factors

The fuel consumption factors developed by Air Sciences Incorporated were used for cereal grains.[53] The consumption factor was 0.59 during spring and 0.60 during fall. The consumption factor for all other crop types was assumed to be 1.00 due to a lack of any specific information. This assumption will tend to overestimate emissions, and may be revisited in the future. Tables showing acreage and tons burned (consumed) are shown below.

Table 3-17. Agricultural Acres Permitted for Burning*

County	Cereal Grains	Corn	Grass, Hay, Pasture, and CRP**	Other
Adams	4,433	42	20	1,517
Asotin			172	60
Columbia	41,397		1,348	200
Douglas				9
Franklin	10,769	3,159		1,278
Garfield	13,321		2,304	260
Grant	5,479	3,579	172	103
Grays Harbor				3
Jefferson				5
Kittitas	235		230	34
Lincoln	2,039		302	463
Okanogan	100		62	
Skagit				600
Spokane				227
Stevens				15
Thurston				8
Walla Walla	50,891		14,019	301
Whitman	36,795		1,199	910
Total	**165,457**	**6,780**	**19,828**	**5,993**

* Conservation Reserve Program conversion
** Excludes Orchard-related and other permits issued for tonnage instead of acres.

Table 3-18. Tons of Agricultural Residue Burned (Consumed)					
County	**Cereal Grains**	**Corn**	**Grass, Hay, Pasture, and CRP***	**Orchard, Trees**	**Other**
Adams	7,141	63	70	98	2,551
Asotin			1,118		25
Benton				23,997	
Chelan				1,796	70
Columbia	106,213		6,865		870
Douglas				4,898	50
Franklin	28,961	21,548		705	765
Garfield	30,778		10,066		40
Grant	6,763	9,128	444	8,155	1,179
Grays Harbor					10
Island				99	
Jefferson					40
Kittitas	1,054		933	22	230
Klickitat				44	56
Lincoln	4,923		453		1,785
Okanogan	266		117	1,127	
Skagit				510	1,248
Spokane					450
Stevens					30
Thurston				145	26
Walla Walla	146,959		14,652	580	247
Whatcom				684	
Whitman	92,148		3,727		1,757
Total	**425,206**	**30,739**	**38,446**	**42,859**	**11,426**
* Conservation Reserve Program conversion					

3.10.2 Emission Rates

Emission rates were taken from EPA's AP42 (PM, VOC, CO, NO_X), a San Joaquin Valley study (NO_X)[55], and the Air Sciences Incorporated report (PM_{10}, $PM_{2.5}$, CH_4).[53]

For crop/vegetation types using AP42 total PM factors, PM_{10} and $PM_{2.5}$ were estimated from total particulate using profiles from the Air Resources Board in California (CARB).[56] The Air Sciences emission rates for cereal grains included PM_{10} and $PM_{2.5}$. CARB profiles used are shown below:

Table 3-19. PM Size Fractions			
Profile	Description	PM_{10} Fraction	$PM_{2.5}$ Fraction
430	field crops	0.9835	0.9379
434	corn	0.9850	0.9438
450	orchard prunings	0.9814	0.9252
452	walnut prunings	0.9799	0.9202
464	timber/brush	0.9610	0.8544
465	pine slash burning	0.9573	0.8672

The Air Sciences report estimated methane, but not VOC. The AP24 ratio of non-methane hydrocarbons to methane (approximately 3.33) was used to estimate non-methane emission rates from the Air Sciences reported methane rates.

The Air Sciences report estimated methane, but not VOC. The AP24 ratio of non-methane hydrocarbons to methane (approximately 3.33) was used to estimate non-methane emission rates from the Air Sciences reported methane rates.

Toxics emission rates were not estimated due to lack of data. The Air Sciences study tested four samples for benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluroanthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and idenol(1,2,3-cd)pyrene. Dibenzo(a,h)anthracene and idenol(1,2,3-cd)pyrene were detected in two of the tests, while the others were not detected in any of the samples. The factors are not used in this inventory.

Table 3-20. Emission Rates in Pounds Per Ton Residue Burned								
Crop	Burn Season	CO	NO_X	PM	PM_{10}	$PM_{2.5}$	SO_2	VOC
Barley	spring	67	5.1	6.8	6.8	6.8	0.1	5.3
Barley	fall	117	5.1	12.3	12.3	12.3	0.1	12
Oats	spring	67	4.5	6.8	6.8	6.8	0.6	5.3
Oats	fall	117	4.5	12.3	12.3	12.3	0.6	12
Wheat and triticale	spring	67	4.3	6.8	6.8	6.8	0.9	5.3
Wheat and triticale	fall	117	4.3	12.3	12.3	12.3	0.9	12
Corn	all	108	3.3	14	13.8	13.2	0.4	12
Bale	all	67	4.3	6.8	6.8	6.8	0.9	5.3
CRP*, grass, pasture	all	101	4.5	16	15.7	15.0	0.6	15
Hay - Alfalfa	all	106	4.5	45	44.3	42.2	0.6	28
Hay - Other	all	139	4.5	32	31.5	30.0	0.6	17
Apple	all	42	5.2	4	3.9	3.7	0.1	3
Apricot	all	49	5.2	6	5.9	5.6	0.1	6

Table 3-20. Emission Rates in Pounds Per Ton Residue Burned								
Crop	Burn Season	CO	NO_X	PM	PM_{10}	$PM_{2.5}$	SO_2	VOC
Cherry	all	44	5.2	8	7.9	7.4	0.1	8
Mixed fruit trees	all	42	5.2	4	3.9	3.7	0.1	3
Nut	all	47	4.5	6	5.9	5.5	0.2	6
Peach	all	42	5.2	6	5.9	5.6	0.1	4
Pear	all	57	5.2	9	8.8	8.3	0.1	7
Plum	all	47	5.2	3	2.9	2.8	0.1	6
Berries	all	117	5.2	21	20.7	19.7	0.1	18
Asparagus	all	150	4.5	40	39.3	37.5	0.6	66
Beans, legumes, lentils	all	186	5.2	43	42.3	40.3	0.1	36
Peas	all	147	5.2	31	30.5	29.1	0.1	29
Potatoes	all	117	4.5	21	20.7	19.7	0.6	18
Vineyards	all	117	5.2	21	20.7	19.7	0.1	18
Watermelon	all	51	4.5	5	4.9	4.7	0.6	5
Other Crops	all	117	5.2	21	20.7	19.7	0.1	18
Flower Bulbs	all	117	4.5	21	20.7	19.7	0.6	18
Nursery Stock	all	117	4.5	21	20.7	19.7	0.6	18
Christmas Trees	all	90	4.3	4	3.8	3.5	0.1	4
Limbs & Brush	all	140	4.3	17	16.3	14.5	0.1	19
Ornamental Bushes	all	140	5.2	17	16.7	15.9	0.1	19
Willow	all	140	5.2	17	16.3	14.5	0.1	19
Sagebrush	all	78	5.2	23	16.0	16.0	0.1	3.4
Building	all	130	1.0	20	19.6	18.3	0.1	11
* Conservation Reserve Program conversion								

3.10.3 Spatial and Temporal Adjustments

All burn data was available by county and date, so neither spatial nor temporal adjustments were necessary.

3.10.4 Emissions Estimates

Emissions estimates were calculated with the equations below.

tpy = (tons consumed) x (pollutant lb/T) x (1 T/2000 lb)
tps = (tons consumed) x (pollutant lb/T) x (1 T/2000 lb)
where the tons burned is the amount burned in the given season

3.11 Residential Yard Waste Burning Leaf and Brush

Residential yard waste burning is outdoor burning of vegetative material.

3.11.1 Activity Level and Spatial Allocation

The measure of activity for residential yard waste burning is the amount of material burned. For the 2011 National Emissions Inventory, leaf and brush are separated into different reporting categories and have different criteria pollutant emission factors. In 2001, Washington State University under contract to the Idaho Department of Environmental Quality conducted a telephone survey of wood heating and outdoor burning habits in Idaho, Oregon and Washington.[57] The survey included questions to estimate the fraction of households that burned yard waste and the number of legal size piles (4') burned per household per year.

In Washington, the survey defined four geographic groups in Washington: 1) incorporated cities, 2) unincorporated western WA, 3) unincorporated eastern WA with forest lands, and 4) unincorporated eastern WA without forest lands. Each county's incorporated areas were assigned to the first group. Unincorporated areas were assigned to one of the last three groups. An estimate of the number of households in each county may be found in Table 2-1.

County unincorporated area assignments were:
western WA: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, Whatcom
eastern WA w/forest: Chelan, Columbia, Douglas, Ferry, Kittitas, Klickitat, Okanogan, Pend Oreille, Spokane, Stevens, Walla Walla, Yakima
eastern WA w/o forest. Adams, Asotin, Benton, Franklin, Garfield, Grant, Lincoln, Whitman

The fractions of households burning yard waste, and the number of piles burned are shown in the table below.

Table 3-21. Amount of Yard Waste Burning

Area	Fraction Burning	Piles Per Year
Incorporated	0.077	2.56
Eastern WA w/forest	0.184	3.64
Eastern WA w/o forest	0.210	2.84
Western WA	0.265	3.37

It was estimated that the weight of a legal size pile was approximately 125 lb.[58] The tons of material burned was estimated using the following equation:

HH x (fraction burning waste) x (piles/HH) x (lb burned/pile) x (1 T/2000 lb),
where HH = the number of households (**Error! Reference source not found.**)

3.11.2 Emission Rates

Criteria and toxic pollutant emission rates for brush and leaf residential yard waste burning were taken from the EPA's Emission Inventory documentation repository for 2011 for the Open

Burning Yard Waste Leaf and Brush category.[59] Emission rates are given in pounds of pollutant per ton of material burned.

Table 3-22. Emission Rates in Pounds Per Ton Material Burned

Pollutant Code	Pollutant Name	Brush Emission Rate (lb/ton)	Leaf Emission Rate (lb/ton)
VOC	Volatile Organic Compounds	19	28
PM_{10}-FIL	PM_{10} Filterable	19.73	22
PM_{10}-PRI	PM_{10} Primary (Filt + Cond)	19.73	22
$PM_{2.5}$-FIL	$PM_{2.5}$ Filterable	15.21	16.9598
$PM_{2.5}$-PRI	$PM_{2.5}$ Primary (Filt + Cond)	15.21	16.9598
NO_X	Nitrogen Oxides	5	6.2
SO_2	Sulfur Dioxide	1.66	0.76
CO	Carbon Monoxide	140	112
67562394	1,2,3,4,6,7,8-Heptachlorodibenzofuran	5.08E-08	5.08E-08
35822469	1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	3.32E-07	3.32E-07
55673897	1,2,3,4,7,8,9-Heptachlorodibenzofuran	6.12E-09	6.12E-09
70648269	1,2,3,4,7,8-Hexachlorodibenzofuran	3.34E-08	3.34E-08
39227286	1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	1.136E-08	1.136E-08
57117449	1,2,3,6,7,8-Hexachlorodibenzofuran	1.428E-08	1.428E-08
57653857	1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	2.14E-08	2.14E-08
72918219	1,2,3,7,8,9-Hexachlorodibenzofuran	2.22E-09	2.22E-09
19408743	1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	3.46E-08	3.46E-08
57117416	1,2,3,7,8-Pentachlorodibenzofuran	1.27E-06	1.27E-06
40321764	1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	7.66E-09	7.66E-09
60851345	2,3,4,6,7,8-Hexachlorodibenzofuran	1.962E-08	1.962E-08
57117314	2,3,4,7,8-Pentachlorodibenzofuran	2.02E-08	2.02E-08
51207319	2,3,7,8-Tetrachlorodibenzofuran	1.396E-08	1.396E-08
1746016	2,3,7,8-Tetrachlorodibenzo-p-Dioxin	2.3E-09	2.3E-09
98828	Cumene	0.01325	0.01325
100414	Ethyl Benzene	0.048	0.048
39001020	Octachlorodibenzofuran	2.06E-08	2.06E-08

Table 3-22. Emission Rates in Pounds Per Ton Material Burned			
Pollutant Code	**Pollutant Name**	**Brush Emission Rate (lb/ton)**	**Leaf Emission Rate (lb/ton)**
3268879	Octachlorodibenzo-p-Dioxin	1.33E-06	1.33E-06
108952	Phenol	0.115	0.115
100425	Styrene	0.1015	0.1015

3.11.3 Temporal Allocation

The survey included questions about seasonal burning habits. The fractions of activity occurring in each season are shown in Table 3-23 below.

Table 3-23. Seasonal Activity Fractions, Residential Yard Waste Burning				
Area	**Fall**	**Winter**	**Spring**	**Summer**
Incorporated	0.25	0.25	0.21	0.29
Eastern WA w/forest	0.23	0.31	0.17	0.29
Eastern WA w/o forest	0.23	0.30	0.19	0.28
Western WA	0.21	0.28	0.22	0.29

3.11.4 Emissions Estimates

Emissions estimates were calculated with the equations below.

tpy = (tons burned) x (pollutant lb/ton) x (ton/2000 lb)
tps = (tpy) x (seasonal fraction)
where: tpy = tons per year, tps = tons per season

3.12 Municipal Solid Waste Burning

Municipal Solid Waste Burning is outdoor burning of household waste.

3.12.1 Activity Level and Spatial Allocation

The measure of activity for residential trash burning is the amount of material burned. The Washington State University telephone survey of wood heating and outdoor burning habits in Idaho, Oregon, and Washington described in Section 3.11 above included questions to estimate the fraction of households that burned trash. The geographic subgroups, county assignments, and number of households in each subgroup were the same as in Section 3.11. The fractions of households burning trash are shown in the table below.

Table 3-24. Fraction of Households Burning Trash	
Area	**Fraction Burning**
Incorporated	0.050
Eastern WA w/forest	0.122
Eastern WA w/o forest	0.114
Western WA	0.199

The amount of trash burned per household was taken from an Emission Inventory Improvement Program (EIIP) recommendation. The EIIP reported that 6.75 lb of total refuse were generated per household per day. Eighty percent (5.37 lb) of the total is combustible and 50% (3.38 lb) is actually consumed when burned.[60]

The tons of material actually consumed were estimated using the following equation:

HH x (fraction of HH burning trash) x (3.38 lb/HH-day) x (365 days) x (1 T/2000 lb),
where: HH = the number of households (Table 2-1)

3.12.2 Emission Rates

Criteria and toxic pollutant emission rates for brush and leaf residential yard waste burning were taken from the EPA's Emission Inventory documentation repository for 2011 for the Open Burning MSW category.[61] Emission rates are given in pounds of pollutant per ton of material consumed.

Table 3-25. Emission Rates in Pounds Per Ton Material Burned					
Description	**Emission Rate**	**Emission Rate Units**	**Description (cont'd)**	**Emission Rate (cont'd)**	**Emission Rate Units (cont'd)**
Carbon Monoxide	85	lb/ton	Acetaldehyde	0.857	lb/ton
Nitrogen Oxides	6	lb/ton	Acrolein	0.0619	lb/ton
PM_{10} Filterable	38	lb/ton	Anthracene	0.0036634	lb/ton
PM_{10} Primary (Filt + Cond)	38	lb/ton	Benz[a]Anthracene	0.0044789	lb/ton
$PM_{2.5}$ Filterable	34.8	lb/ton	Benzene	2.48	lb/ton
$PM_{2.5}$ Primary (Filt + Cond)	34.8	lb/ton	Benzo[a]Pyrene	0.0042442	lb/ton
Sulfur Dioxide	1	lb/ton	Benzo[b]Fluoranthene	0.0052601	lb/ton
Volatile Organic Compounds	8.56	lb/ton	Benzo[g,h,i,]Perylene	0.0039488	lb/ton
1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.48E-07	lb/ton	Benzo[k]Fluoranthene	0.0020509	lb/ton
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin	7.96E-08	lb/ton	Chlorobenzene	0.0008484	lb/ton
1,2,3,4,7,8,9-Heptachlorodibenzofuran	3.0E-08	lb/ton	Chrysene	0.0050724	lb/ton

Table 3-25. Emission Rates in Pounds Per Ton Material Burned					
Description	**Emission Rate**	**Emission Rate Units**	**Description (cont'd)**	**Emission Rate (cont'd)**	**Emission Rate Units (cont'd)**
1,2,3,4,7,8-Hexachlorodibenzofuran	2.28E-07	lb/ton	Dibenzo[a,h]Anthracene	0.0006456	lb/ton
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin	1.28E-08	lb/ton	Fluoranthene	0.0081353	lb/ton
1,2,3,6,7,8-Hexachlorodibenzofuran	7.7E-08	lb/ton	Fluorene	0.0073116	lb/ton
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin	1.94E-08	lb/ton	Hexachlorobenzene	4.4E-05	lb/ton
1,2,3,7,8,9-Hexachlorodibenzofuran	5.0E-09	lb/ton	Hydrochloric Acid	0.568	lb/ton
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin	3.8E-07	lb/ton	Hydrogen Cyanide	0.936	lb/ton
1,2,3,7,8-Pentachlorodibenzofuran	7.44E-08	lb/ton	Indeno[1,2,3-c,d]Pyrene	0.0037544	lb/ton
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin	1.62E-08	lb/ton	Naphthalene	0.035063	lb/ton
1,2,4-Trichlorobenzene	1.95E-04	lb/ton	Octachlorodibenzofuran	7.28E-08	lb/ton
1,4-Dichlorobenzene	6.65E-05	lb/ton	Octachlorodibenzo-p-Dioxin	9.94E-08	lb/ton
2,3,4,6,7,8-Hexachlorodibenzofuran	1.238E-07	lb/ton	Pentachlorophenol	0.000106	lb/ton
2,3,4,7,8-Pentachlorodibenzofuran	1.304E-07	lb/ton	Phenanthrene	0.0146492	lb/ton
2,3,7,8-Tetrachlorodibenzofuran	9.12E-08	lb/ton	Phenol	0.28	lb/ton
2,3,7,8-Tetrachlorodibenzo-p-Dioxin	5.4E-09	lb/ton	Polychlorinated Biphenyls	0.00572	lb/ton
Acenaphthene	1.54E-03	lb/ton	Pyrene	0.0096576	lb/ton
Acenaphthylene	0.0226	lb/ton	Styrene	1.48	lb/ton

3.12.3 Temporal Allocation

Trash burning is assumed to be uniform year-round.

3.12.4 Emissions Estimates

Emissions estimates were calculated with the equations below.

tpy = (tons consumed) x (pollutant lb/T) x (1 T/2000 lb)
tps = (tpy) / 4
where: tpy = tons per year, tps = tons per season

3.13 Gasoline Service Stations

Emissions from gasoline service stations result from evaporation of gasoline vapors during underground tank filling, underground tank breathing and emptying, and vehicle refueling. Losses from trucks transporting fuel are also included here.

Underground tank filling in Washington is controlled by use of vapor balance systems known as Stage I control. Controls for vehicle refueling include onboard canisters and at-the-pump special nozzles, both of which capture vapors from the vehicle gas tank during refueling. At-the-pump control is known as Stage II.

3.13.1 Activity Level, Temporal and Spatial Allocation

The measure of activity is gallons of gasoline distributed in the county. The local air authorities were contacted for the number of gallons distributed by county and information on control strategies utilized (Stage I and Stage II). We received data from the following counties for gallons distributed: Clark, Cowlitz, Island, Lewis, Skagit, Skamania, Wahkiakum, and Whatcom. For counties that did not report the amount of gasoline distributed, we utilized the percentage of licensed vehicles[62] per county and the total gallons of gasoline sold in the state to estimate gallons per county using the equation below:

County annual gallons = (County licensed vehicles/Total licensed vehicles in Washington) x Total Gallons Gasoline sold in State

Table 3-26. Gallons of Gasoline Distributed

County	Gallons		County	Gallons
Adams	7,625,435		Lewis	37,499,539
Asotin	8,507,669		Lincoln	5,583,942
Benton	70,107,835		Mason	27,507,552
Chelan	33,095,355		Okanogan	18,748,436
Clallam	31,139,286		Pacific	9,908,722
Clark	142,552,199		Pend Oreille	6,742,236
Columbia	1,850,857		Pierce	290,270,885
Cowlitz	47,525,772		San Juan	8,403,423
Douglas	15,779,825		Skagit	50,408,045
Ferry	3,508,183		Skamania	1,573,544
Franklin	31,107,915		Snohomish	274,454,381
Garfield	1,049,704		Spokane	146,756,920
Grant	37,927,371		Stevens	22,101,214
Grays Harbor	29,491,613		Thurston	106,162,952
Island	19,283,068		Wahkiakum	794,463
Jefferson	14,671,241		Walla Walla	22,200,152
King	695,952,253		Whatcom	117,328,698
Kitsap	101,719,447		Whitman	13,726,749
Kittitas	17,529,332		Yakima	97,164,456
Klickitat	9,810,750		**State Total**	**2,577,571,419**

3.13.2 Emission Rates

Underground Tank Filling, Breathing and Emptying, Transit Losses
Emission rates for underground tank filling, breathing and emptying, and transit losses were taken from documentation released by the EPA for gasoline distribution for the 2011 National Emissions Inventory (NEI).[63] Per the local air authorities, all underground tank filling was assumed to be controlled using a vapor balance system to recover displaced gasoline vapors as the tank is filled (stage I). EPA estimates that the control efficiency for stage I ranges from 93% - 100%. The AP42 emission factor is the midpoint of the range and was used for all underground tank filling in this inventory. Stage I malfunction rates were not considered in this inventory due to the lack of statewide information; therefore, actual emissions from underground tank filling may be somewhat higher than those calculated here.

Vehicle Refueling
Emission rates for vehicle refueling are calculated by MOVES using input files with data from regional offices and local air authorities. Stage II vapor recovery system emission factors are utilized in this category as well as uncontrolled emission factors.

Stage II vapor recovery systems collect gasoline vapors from vehicle fuel tanks while customers dispense gasoline products into their vehicles at gasoline stations. Use of this technology controls the amount of pollutants released during vehicle refueling; therefore, emission factors for pollutants are variable depending on whether or not stage II vapor recovery systems are used at the gasoline station. Emission factors for both uncontrolled and stage II emissions were calculated for this inventory using MOVES.

Three local authorities provided data used to determine the amount of gallons distributed in the counties they have jurisdiction over (Southwest, Benton and Spokane Regional Clean Air Agencies). This local data was used to calculate VOC and toxic emissions from those counties using the emission factors and VOC speciation data in Table 3-28 and **Table 3-29**.

The counties which require stage II vapor recovery are Clark, Cowlitz, King, Kitsap, Pierce, and Snohomish. Stage II vapor recovery is also required for very large stations near residences in other counties.[64]

Two of the local air authorities supplied the amount of gasoline dispensed with and without stage II controls (Northwest Clean Air Agency and Southwest Clean Air Agency)).[65,66] This data was used to calculate VOC and toxics emissions as well as stage II fractions of gasoline. Two local air authorities provided the number of stations with and without stage II control (Olympic Regional Clean Air Agency and Spokane Regional Clean Air Agency). [67, 68] That data was used to calculate stage II fractions for counties within those jurisdictions.

Counties with reported stage II fractions and those counties with a stage II vapor recovery requirement are listed in **Table 3-27** with the corresponding stage II fraction. Counties not listed were assumed to have no stage II controls for MOVES runs. Stations with stage II control are generally the stations with the largest throughput and this method may underestimate the fraction of stage II controlled gallons dispensed.

Table 3-27. County Stage II Fraction	
County	**Stage II Fraction**
Clallam	0.148
Clark	0.633
Cowlitz	0.294
Grays Harbor	0.103
Island	0.346
Jefferson	0.158
Lewis	0.084
King	0.86
Kitsap	0.86
Mason	0.088
Pacific	0.063
Skagit	0.161
Skamania	0.00
Snohomish	0.86
Spokane	0.27
Thurston	0.383
Wahkiakum	0.00
Whatcom	0.194

Emission rates for vehicle refueling vary by county. Sample VOC rates are shown in Table 3-28. Toxics are calculated as a percentage of the VOC emissions and are shown in Table 3-29.

Table 3-28. Gasoline Station VOC Emission Rates						
Source	**Units**	**Season**	**County Emission Rates**			
			Clark	**King**	**Spokane**	**Yakima**
Underground tank filling	lb/1000 gal	All	0.3	0.3	0.3	0.3
Breathing and emptying	lb/1000 gal	All	1	1	1	1
Transit	lb/1000 gal	All	0.06	0.06	0.06	0.06
Vehicle refueling (uncontrolled/Stage II)	lb/1000 gal	Winter	5.24/.89	(n/a)/.78	4.26/.77	5.15/(n/a)
		Spring	4.72/.82	(n/a)/.74	4.96/.87	5.97/(n/a)
		Summer	3.88/.70	(n/a)/.67	4.93/.86	5.86/(n/a)
		Fall	3.13/.60	(n/a)/.59	3.62/.68	4.37/(n/a)

Table 3-29. Gasoline Station VOC Speciation for Toxics		
Name	**CAS**	**Percent of VOC**
2,2,4-Trimethylpentane	540841	0.75%
Cumene	98828	0.012%
Ethyl Benzene	100414	0.053%
n-Hexane	110543	1.8%
Naphthalene	91203	.00027%
Toluene	108883	1.4%
Xylenes	1330207	0.56%
Benzene	71432	Varies by county, 1.12%-1.20%

3.14 Solvent Utilization

Solvent utilization encompasses activities utilizing solvents such as degreasing, dry cleaning, and surface coating where the primary pollutants released are volatile organic compounds (VOCs) and toxics. Table 3-34 contains a list of each category and the activity data used to calculate emissions (activity data will be discussed in the next section).

Table 3-30. Solvent Utilization Categories and Source of Activity Data		
SCC	**Category**	**Activity Data**
2401075000	Aircraft manufacturing	Adjusted County Employment
2401060000	Appliances	Adjusted County Employment
2401001000	Architectural coating	Population
2401005000	Automobile refinishing	Adjusted County Employment
2420000000	Dry cleaning	Adjusted County Employment
2401065000	Electronic and other electrical coatings	Adjusted County Employment
2401015000	Factory finished wood (wood and comp flat stock)	Adjusted County Employment
2425000000	Graphic arts	Adjusted County Employment
2415000000	Industrial and institutional degreasing	Adjusted County Employment
2401100000	Industrial maintenance	Population
2401055000	Machinery and equipment	Adjusted County Employment
2401080000	Marine manufacturing	Adjusted County Employment
2401040000	Metal cans	Adjusted County Employment
2401025000	Metal furniture	Adjusted County Employment
2401090000	Miscellaneous manufacturing	Adjusted County Employment
2401070000	Motor vehicles and parts	Adjusted County Employment
2401030000	Paper, film, foil	Adjusted County Employment
2401085000	Railroad	Adjusted County Employment
2401200000	Special purpose coating	Population
2401020000	Wood furniture	Adjusted County Employment

3.14.1 Activity Level and Spatial Allocation

The activity level for these categories is either number of employees within the source category in the county or population of the county. Population data was readily available and can be found in Table 2-1. The only data that the Department of Ecology could easily obtain for County Employee statistics was the Employment Security Department's (ESD) 2011 Annual Averages of Quarterly Census of Employment and Wages report. This data can be kept confidential at the reporting business' request. In order to maximize the use of reported employment data, the approach detailed below was used.

Although a good deal of the data at the more descriptive NAICS level (e.g. 336340 as compared to 33) was restricted by County, data reported for the State was often reported at the more descriptive level (336340). A ratio was developed using this data. For each source category that used number of employees in a sector to calculate emissions, the State-level sum of employees at the more descriptive level was divided by the total number of State employees at the less descriptive level.

For example, the following numbers were reported for transportation equipment manufacturing category (336) and the more descriptive *aircraft transportation* manufacturing category (3364):

Total State Employees in NAICS 336: 95,678 (annual average)
Total State Employees in NAICS 3364: 86,080 (annual average)

NAICS 3364 as a percentage of NAICS 336 is 89.9% at the State level.

County numbers are often blocked at the 3364 level but would have a total number of employees that were employed in 336. Extrapolating to the County, at least 89.9% of those employees would be working in aircraft transportation manufacturing (3364). For example:

King County reports that they have 45,730 employees working in NAICS level 336. Therefore:

45,730 * 89.9% = 41,143 employees working in 3364

The EPA estimated number of employees for this NAICS category in King County at 16,626. This is significantly less than the estimate calculated using the method above and would under estimate emissions for this category at 12.98 lb VOC per employee.

This method was used for each SCC code that had sufficient NAICS data reported by ESD. Unfortunately, some of the State level data is also kept confidential. In that case, the emissions reported by EPA for the corresponding SCC were accepted.

3.14.2 Temporal Allocation

Temporal allocation of emissions was achieved using temporal profiles from the current version of AIRPACT. Although there is some variation, the categories are roughly allocated evenly throughout the year with 25% attributed to each season, as shown in Table 3-31.

Table 3-31. Solvent Utilization Seasonal Allocation (Percent)				
Category	Winter (Dec-Feb)	Spring (Mar-May)	Summer (Jun-Aug)	Fall (Sep-Nov)
Aircraft manufacturing	24	24	26	26
Appliances	25	25	25	25
Architectural coating	25	25	25	25
Automobile refinishing	25	25	25	25
Dry cleaning	25	24	26	26
Electronic and other electrical coatings	25	24	25	26
Factory finished wood (wood and comp flat stock)	24	25	26	25
Graphic arts	25	25	25	25
Industrial and institutional degreasing	25	24	25	26
Industrial maintenance	25	24	25	25
Machinery and equipment	25	24	25	26
Marine manufacturing	25	25	25	25
Metal cans	25	24	25	26
Metal furniture	25	24	25	26
Miscellaneous manufacturing	25	24	25	25
Motor vehicles and parts	24	24	26	26
Paper, film, foil	25	25	25	25
Railroad	24	24	26	26
Special purpose coating	25	24	25	25
Wood furniture	25	24	25	26

3.14.3 Emission Rates

Criteria and toxic pollutant emission rates for solvent utilization categories were taken from the EPA's Emission Inventory documentation repository for 2011 for the solvent utilization categories listed above.[69] The emission factors were developed by the Eastern Regional Technical Assistance Committee (ERTAC). The committee is a collection of states in the eastern region that review emission inventory methods developed by the EPA.

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	Pollutant	Emission Factor	EF Numerator
Degreasing: All Processes/All Industries	Trichloroethylene	0.21	lb/person or employee
Degreasing: All Processes/All Industries	Volatile Organic Compounds	36.97	lb/person or employee
Dry Cleaning: All Processes	Tetrachloroethylene	93.00	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Dry Cleaning: All Processes	Volatile Organic Compounds	10.00	lb/person or employee
Graphic Arts: All Processes	Cumene	0.20	lb/person or employee
Graphic Arts: All Processes	Diethanolamine	0.04	lb/person or employee
Graphic Arts: All Processes	Ethyl Benzene	0.18	lb/person or employee
Graphic Arts: All Processes	Ethylene Glycol	0.99	lb/person or employee
Graphic Arts: All Processes	Glycol Ethers	4.36	lb/person or employee
Graphic Arts: All Processes	Hexane	0.09	lb/person or employee
Graphic Arts: All Processes	Isophorone	0.01	lb/person or employee
Graphic Arts: All Processes	Methanol	0.69	lb/person or employee
Graphic Arts: All Processes	Methyl Chloroform	0.00	lb/person or employee
Graphic Arts: All Processes	Methyl Isobutyl Ketone	0.18	lb/person or employee
Graphic Arts: All Processes	Methylene Chloride	0.20	lb/person or employee
Graphic Arts: All Processes	Naphthalene	0.09	lb/person or employee
Graphic Arts: All Processes	p-Dioxane	0.04	lb/person or employee
Graphic Arts: All Processes	Tetrachloroethylene	0.04	lb/person or employee
Graphic Arts: All Processes	Toluene	2.63	lb/person or employee
Graphic Arts: All Processes	Triethylamine	0.04	lb/person or employee
Graphic Arts: All Processes	Volatile Organic Compounds	201.00	lb/person or employee
Graphic Arts: All Processes	Xylenes (Mixed Isomers)	2.13	lb/person or employee
Surface Coating: Aircraft: SIC 372	Ethyl Benzene	7.80E-02	lb/person or employee
Surface Coating: Aircraft: SIC 372	Hexane	3.07	lb/person or employee
Surface Coating: Aircraft: SIC 372	Methyl Isobutyl Ketone	0.31	lb/person or employee
Surface Coating: Aircraft: SIC 372	m-Xylene	0.16	lb/person or employee
Surface Coating: Aircraft: SIC 372	o-Xylene	7.14E-02	lb/person or employee
Surface Coating: Aircraft: SIC 372	p-Xylene	7.24E-02	lb/person or employee
Surface Coating: Aircraft: SIC 372	Tert-butyl Acetate	0.33	lb/person or employee
Surface Coating: Aircraft: SIC 372	Toluene	1.68	lb/person or employee
Surface Coating: Aircraft: SIC 372	Triethylamine	6.36E-03	lb/person or employee
Surface Coating: Aircraft: SIC 372	Volatile Organic Compounds	12.98	lb/person or employee
Surface Coating: Architectural Coatings	Ethyl Benzene	1.48E-02	lb/person or employee
Surface Coating: Architectural Coatings	Hexane	0.55	lb/person or employee
Surface Coating: Architectural Coatings	Methyl Isobutyl Ketone	9.27E-02	lb/person or employee
Surface Coating: Architectural Coatings	m-Xylene	3.06E-02	lb/person or employee
Surface Coating: Architectural Coatings	o-Xylene	1.35E-02	lb/person or employee
Surface Coating: Architectural Coatings	p-Xylene	1.36E-02	lb/person or employee
Surface Coating: Architectural Coatings	Tert-butyl Acetate	5.85E-02	lb/person or employee
Surface Coating: Architectural Coatings	Toluene	0.29	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Architectural Coatings	Triethylamine	1.10E-03	lb/person or employee
Surface Coating: Architectural Coatings	Volatile Organic Compounds	2.34	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	2-Butoxyethyl Acetate	0.86	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Ethyl Benzene	0.66	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Hexane	24.57	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Methanol	0.27	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Methyl Isobutyl Ketone	5.09	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Methyl Methacrylate	9.47E-02	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	m-Xylene	1.54	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	o-Xylene	0.76	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Propyl Cellosolve	0.63	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	p-Xylene	0.65	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Tert-butyl Acetate	4.91	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Toluene	12.63	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Triethylamine	4.64E-02	lb/person or employee
Surface Coating: Auto Refinishing: SIC 7532	Volatile Organic Compounds	94.69	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Ethyl Benzene	0.20	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Hexane	7.54	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Methyl Isobutyl Ketone	1.26	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	m-Xylene	0.42	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	o-Xylene	0.18	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	p-Xylene	0.19	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Tert-butyl Acetate	0.80	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Toluene	3.99	lb/person or employee
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Triethylamine	1.50E-02	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Electronic and Other Electrical: SIC 36 - 363	Volatile Organic Compounds	31.92	lb/person or employee
Surface Coating: Factory Finished Wood: SIC 2426 thru 242	Volatile Organic Compounds	48.07	lb/person or employee
Surface Coating: Factory Finished Wood: SIC 2426 thru 242	Xylenes (Mixed Isomers)	2.38	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Ethyl Benzene	3.81E-03	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Hexane	0.14	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Methyl Isobutyl Ketone	2.39E-02	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	m-Xylene	7.89E-03	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	o-Xylene	3.47E-03	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	p-Xylene	3.52E-03	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Tert-butyl Acetate	1.51E-02	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Toluene	7.54E-02	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Triethylamine	2.83E-04	lb/person or employee
Surface Coating: Industrial Maintenance Coatings	Volatile Organic Compounds	0.60	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Ethyl Benzene	1.40	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Hexane	49.35	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Methyl Isobutyl Ketone	14.40	lb/person or employee
Surface Coating: Large Appliances: SIC 363	m-Xylene	3.02	lb/person or employee
Surface Coating: Large Appliances: SIC 363	o-Xylene	1.32	lb/person or employee
Surface Coating: Large Appliances: SIC 363	p-Xylene	1.34	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Tert-butyl Acetate	5.22	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Toluene	26.35	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Triethylamine	9.82E-02	lb/person or employee
Surface Coating: Large Appliances: SIC 363	Volatile Organic Compounds	208.83	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Ethyl Benzene	0.33	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Machinery and Equipment: SIC 35	Hexane	12.20	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Methyl Isobutyl Ketone	2.05	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	m-Xylene	0.68	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	o-Xylene	0.30	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	p-Xylene	0.30	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Tert-butyl Acetate	1.29	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Toluene	6.46	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Triethylamine	0.0242708	lb/person or employee
Surface Coating: Machinery and Equipment: SIC 35	Volatile Organic Compounds	51.64	lb/person or employee
Surface Coating: Marine: SIC 373	Propyl Cellosolve	2.61	lb/person or employee
Surface Coating: Marine: SIC 373	Volatile Organic Compounds	225.40	lb/person or employee
Surface Coating: Metal Cans: SIC 341	Ethylene Glycol	886.22	lb/person or employee
Surface Coating: Metal Cans: SIC 341	Methanol	406.69	lb/person or employee
Surface Coating: Metal Cans: SIC 341	Toluene	813.38	lb/person or employee
Surface Coating: Metal Cans: SIC 341	Volatile Organic Compounds	3035.00	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Ethyl Benzene	5.60	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Hexane	209.82	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Methyl Isobutyl Ketone	35.17	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	m-Xylene	11.61	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	o-Xylene	5.10	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	p-Xylene	5.18	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Tert-butyl Acetate	22.18	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Toluene	110.99	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Triethylamine	0.42	lb/person or employee
Surface Coating: Metal Furniture: SIC 25	Volatile Organic Compounds	887.80	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Ethyl Benzene	0.58	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Hexane	21.84	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Methyl Isobutyl Ketone	3.66	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	m-Xylene	1.21	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Miscellaneous Manufacturing	o-Xylene	0.53	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	p-Xylene	0.54	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Tert-butyl Acetate	2.31	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Toluene	11.55	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Triethylamine	4.34E-02	lb/person or employee
Surface Coating: Miscellaneous Manufacturing	Volatile Organic Compounds	92.42	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	2-Butoxyethyl Acetate	1.76	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Ethyl Benzene	1.37	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Hexane	50.59	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Methanol	0.56	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Methyl Isobutyl Ketone	10.47	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Methyl Methacrylate	0.20	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	m-Xylene	3.17	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	o-Xylene	1.57	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Propyl Cellosolve	1.30	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	p-Xylene	1.34	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Tert-butyl Acetate	10.11	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Toluene	26.00	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Triethylamine	9.56E-02	lb/person or employee
Surface Coating: Motor Vehicles: SIC 371	Volatile Organic Compounds	195.00	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Ethylene Glycol	3.15E-05	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Glycol Ethers	9.67E-05	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Methyl Chloroform	5.60E-05	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Methyl Isobutyl Ketone	5.81E-04	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Toluene	1.82E-04	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Volatile Organic Compounds	6.43E-03	lb/person or employee
Surface Coating: Other Special Purpose Coatings	Xylenes (Mixed Isomers)	0.00	lb/person or employee
Surface Coating: Paper: SIC 26	Ethyl Benzene	3.84	lb/person or employee
Surface Coating: Paper: SIC 26	Hexane	143.93	lb/person or employee
Surface Coating: Paper: SIC 26	Methyl Isobutyl Ketone	24.13	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Paper: SIC 26	m-Xylene	7.97	lb/person or employee
Surface Coating: Paper: SIC 26	o-Xylene	3.50	lb/person or employee
Surface Coating: Paper: SIC 26	p-Xylene	3.55	lb/person or employee
Surface Coating: Paper: SIC 26	Tert-butyl Acetate	15.21	lb/person or employee
Surface Coating: Paper: SIC 26	Toluene	76.14	lb/person or employee
Surface Coating: Paper: SIC 26	Triethylamine	0.29	lb/person or employee
Surface Coating: Paper: SIC 26	Volatile Organic Compounds	609.00	lb/person or employee
Surface Coating: Traffic Markings	1,3-Butadiene	2.90E-04	lb/person or employee
Surface Coating: Traffic Markings	Ethyl Benzene	8.03E-04	lb/person or employee
Surface Coating: Traffic Markings	Naphthalene	1.45E-04	lb/person or employee
Surface Coating: Traffic Markings	Tert-butyl Acetate	8.99E-04	lb/person or employee
Surface Coating: Traffic Markings	Toluene	0.0246674	lb/person or employee
Surface Coating: Traffic Markings	Volatile Organic Compounds	0.29	lb/person or employee
Surface Coating: Traffic Markings	Xylenes (Mixed Isomers)	1.50E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	1,2-Epoxybutane	3.44E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	2-Butoxyethyl Acetate	2.38E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	4,4'-Methylenediphenyl Diisocyanate	4.78E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Acetaldehyde	4.86E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Acrylic Acid	4.78E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Acrylonitrile	1.40E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Benzene	3.36E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Benzo[a]Pyrene	6.25E-10	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Benzyl Chloride	2.56E-07	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Bis(2-Ethylhexyl)Phthalate	0.63	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Butyl Carbitol Acetate	8.89E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Cellosolve Acetate	4.70E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Cellosolve Solvent	8.49E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Chlorobenzene	9.31E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Cumene	0.51	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Cyanide	5.29E-05	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Dibutyl Phthalate	9.48E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Diethanolamine	9.29E-05	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Diethylene Glycol Monobutyl Ether	0.86	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Diethylene Glycol Monoethyl Ether	1.66E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Diethylene Glycol Monomethyl Ether	0.13	lb/person or employee

Table 3-32. Architectural Coating VOC and Toxics Emission Factors			
Solvent Utilization Category	**Pollutant**	**Emission Factor**	**EF Numerator**
Surface Coating: Wood Furniture: SIC 25	Dimethyl Phthalate	2.52E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Ethyl Acrylate	0.27	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Ethyl Benzene	10.46	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Ethylene Glycol	0.18	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Formaldehyde	0.89	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Hexamethylene Diisocyanate	2.00E-04	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Hexane	4.38	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Hydrogen Cyanide	1.70E-04	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Hydroquinone	1.06E-04	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Methanol	27.57	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Methyl Chloroform	41.83	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Methyl Isobutyl Ketone	13.01	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Methyl Methacrylate	1.21E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Methylene Chloride	1.24	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Naphthalene	0.12	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	p-Dioxane	2.68E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Phenol	5.67E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Phenyl Cellosolve	8.49E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Propyl Cellosolve	2.01	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Propylene Oxide	2.19E-04	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Styrene	0.68	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Toluene	81.51	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Trichloroethylene	6.85E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Triethylamine	2.06E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Triethylene glycol	4.44E-03	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Vinyl Acetate	9.83E-02	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Volatile Organic Compounds	524.12	lb/person or employee
Surface Coating: Wood Furniture: SIC 25	Xylenes (Mixed Isomers)	74.80	lb/person or employee

3.14.4 Emissions Estimates

County VOC and toxics emissions were calculated using the following equation:

Emissions = (county population or number of employees) x (lb/person or employee)

3.15 Consumer and Commercial Solvent Use

This category addresses non-industrial solvents that are used in commercial or consumer applications. The solvents may serve as propellants, aid in product drying through evaporation, or act as co-solvents and cleaning agents. Consumer and commercial solvent use was addressed in the EPA-released documents for the 2011 NEI. [70]

3.15.1 Activity Level, Spatial Allocation, and Emission Rates

The EPA recommended method for calculating emissions from solvent use is to multiply national per capita emission rates by local population data. The activity level is based on county population (see Table 2-1), and since population is available by county, no further spatial allocation is necessary.

VOC emission rates for consumer and commercial products were provided by SCC and developed by the Eastern Regional Technical Assistance Committee (ERTAC). The toxic emission rates were provided by the EPA.[70]

The VOC emission factors are shown in Table 3-33. Toxics factors are shown in Table 3-34.

Table 3-33. Consumer and Commercial Solvent VOC Emission Rates

Product Category	lb VOC/Person
Adhesives and sealants	0.57
Automotive aftermarket products	1.36
Coatings and related products	0.95
FIFRA regulated products*	1.78
Household products	1.8
Miscellaneous products	0.07
Personal care products	1.9
TOTAL	**8.43**

* Federal Insecticide, Fungicide and Rodenticide Act

Table 3-34. Consumer and Commercial Solvent Toxics Emission Rates (lb/person)

Pollutant	Adhesives and Sealants	Automotive Aftermarket Products	Coatings and Related Products	FIFRA Regulated Products	Household Products	Misc. Products	Personal Care Products
Ethylene glycol	.16644	.39712	.2774	.51976	.5256	.02044	.5548
Methanol	.07638	.18224	.1273	.23852	.2412	.00938	.2546
Toluene	.15276	.36448	.2546	.47704	.4824	.01876	.5092

3.15.2 Temporal Allocation

All but FIFRA products are assumed to be used uniformly throughout the year.[70] Monthly adjustment factors for the FIRFA products were derived from 2011 quarterly gross income figures for Washington businesses in Retail Trade, Lawn and Garden Supplies (NAICS 4442).[71] The business quarters are defined as Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Dec. Each month was assigned 1/3 of the quarterly activity, and summed to match the inventory seasons: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug), and fall (Sep-Nov).

Table 3-35. Seasonal Allocation for FIFRA Products

Business Quarter (2005)	Gross Income	Inventory Season	Inventory Season Income	Seasonal Fraction
First quarter	170,214,287	Winter	183,400,577	0.21
Second quarter	288,659,852	Spring	249,177,997	0.28
Third quarter	210,242,515	Summer	236,381,627	0.27
Fourth quarter	209,773,157	Fall	209,929,610	0.24
Total	**878,889,811**		**878,889,811**	

3.15.3 Emission Estimates

County seasonal emissions were calculated for each category using the following equation:

(county population) x (emission rate lb/person) x (seasonal fraction) x (1 T/2000 lb)

3.16 Residential Fuel Use, excluding Wood

Residential fuel use was estimated using EPA's Residential Fuel consumption tool, modified with 2010 county level data for WA.[72, 73, 82] The residential non-wood fuels included in this report are distillate oil, natural gas, and liquefied petroleum gas (LPG). Residential wood combustion is treated separately in Section 3.17. Residential coal combustion is not included in the inventory since less than 500 housing units in the state use coal as their heating source (Table 2-1).

3.16.1 Activity Level

Washington State fuel use for 2010 was obtained from the Energy Information Administration and is shown in Table 3-36.[74]

Table 3-36. State Residential Fuel Use

Oil (10^3 gallons)	Natural Gas (10^6 cu ft)	LPG* (10^3 barrels)*
40.908	75,554	2,489
*1 barrel = 42 gallons		

The state-level volume of distillate oil consumed by residential combustion in the U.S. was used to estimate emissions. Energy consumption by energy use sector is presented in State Energy Data 2010 Consumption tables published by the Energy Information Administration (EIA). Year 2010 consumption data were used as a surrogate for 2011 emissions because year 2010 data were the most recent data available when this portion of the inventory was prepared.

3.16.2 Spatial Allocation

State-level consumption was allocated to each county using the Census 2006-2010 American Community Survey 5-year Estimates - 2006-2010 Census Detailed Housing Information. These data include the number of housing units using a specific type of fuel for residential heating. State energy consumption was allocated to each county using the ratio of the number of houses primarily using a specific energy source (LPG, distillate oil, Natural gas) in each county to the total number of houses using the same source in the State.[73]

Table 3-37. Residential Fuel Use by County

	HUs Using Fuel			Fuel Use		
				Oil	Nat Gas	LPG
County	Oil	Natural Gas	LPG	10^3 gal	10^6 cu ft	10^3 barrels
Adams	229	1,623	146	107.26	134.615	3.86063992
Asotin	92	4,789	217	43.09	397.210	5.7380744
Benton	298	9,381	652	139.58	778.080	17.2406659
Chelan	112	1,250	100	52.46	103.678	2.64427392
Clallam	335	406	1,323	156.91	33.674	34.9837439
Clark	1,791	49,892	1,757	838.89	4,138.145	46.4598927
Columbia	301	31	82	140.99	2.571	2.16830461
Cowlitz	253	2,113	461	118.50	175.257	12.1901028
Douglas	108	425	88	50.59	35.250	2.32696105
Ferry	162	40	177	75.88	3.318	4.68036484
Franklin	295	5,503	238	138.18	456.430	6.29337193
Garfield	178	7	98	83.37	0.581	2.59138844
Grant	216	909	195	101.17	75.394	5.15633414
Grays Harbor	634	3,348	1,009	296.96	277.690	26.6807238
Island	1,208	5,710	7,222	565.82	473.599	190.969462
Jefferson	662	296	2,800	310.08	24.551	74.0396697
King	41,742	351,353	11,569	19,551.64	29,141.943	305.91605
Kitsap	5,632	25,295	6,671	2,637.99	2,098.020	176.399513
Kittitas	628	3,704	2,139	294.15	307.217	56.5610191
Klickitat	450	1,576	371	210.78	130.717	9.81025624
Lewis	384	3,258	1,310	179.86	270.225	34.6399883
Lincoln	481	1,333	140	225.30	110.562	3.70198349
Mason	363	1,580	1,621	170.03	131.048	42.8636802

Table 3-37. Residential Fuel Use by County						
	HUs Using Fuel			Fuel Use		
				Oil	Nat Gas	LPG
County	Oil	Natural Gas	LPG	10^3 gal	10^6 cu ft	10^3 barrels
Okanogan	333	198	613	155.97	16.423	16.2093991
Pacific	314	76	520	147.08	6.304	13.7502244
Pend Oreille	41	80	196	19.20	6.635	5.18277688
Pierce	7,893	107,243	6,462	3,697.02	8,894.956	170.872981
San Juan	505	183	1,219	236.54	15.178	32.2336991
Skagit	1,046	20,363	5,076	489.94	1,688.949	134.223344
Skamania	105	559	176	49.18	46.365	4.6539221
Snohomish	4,334	105,776	12,019	2,030.01	8,773.280	317.815282
Spokane	8,360	95,228	3,037	3,915.76	7,898.407	80.3065989
Stevens	476	4,239	1,003	222.95	351.591	26.5220674
Thurston	1,556	35,039	6,070	728.82	2,906.207	160.507427
Wahkiakum	99	0	114	46.37	0.000	3.01447227
Walla Walla	765	8,052	358	358.32	667.850	9.46650063
Whatcom	1,297	34,559	9,019	607.51	2,866.395	238.487065
Whitman	858	4,704	317	401.88	390.159	8.38234832
Yakima	2,801	20,804	2,551	1,311.97	1,725.527	67.4554277
State Totals	**87337**	**910925**	**89136**	**40908**	**75554**	**2357**

3.16.3 Temporal Allocation

Seasonal profiles for this category were taken from temporal files developed for AIRPACT. They are listed below.

Table 3-38. Temporal Allocation for Residential Fuel Use by Fuel Type				
Fuel Type	Winter	Spring	Summer	Fall
Distillate Oil	0.57	0.22	0.02	0.19
Natural Gas	0.57	0.22	0.02	0.19
LPG	0.57	0.22	0.02	0.19

3.16.4 Emission Rates

Criteria and toxic pollutant emission rates for residential fuel use, excluding wood were taken from the EPA's 2011 Emission Inventory documentation and file repository for the residential fuel use category.[75]

Table 3-39. Residential Fuel Use Emission Rates				
Pollutant	Pollutant Code	Oil	LPG	Natural Gas
		lb/10^3 gal	lb/10^3 bbl	lb/10^6 ft^3
CO	CO	5.00E+00	1.60E+02	4.00E+01
NO_X	NO_X	1.80E+01	5.63E+02	9.40E+01
PM_{10} PRI	PM_{10}	2.38E+00	2.07E+00	5.20E-01
$PM_{2.5}$ PRI	$PM_{2.5}$	2.13E+00	1.71E+00	4.30E-01
SO_2	SO_2	4.26E+01	2.39E+00	6.00E-01
VOC	VOC	7.00E-01	2.19E+01	5.50E+00
Acetaldehyde	75070		5.44E-05	1.37E-05
Ammonia	NH_3	1.00E+00	1.95E+00	2.00E+01
Benzene	71432		8.78E-03	2.21E-03
Fluoranthene	206440		1.25E-05	3.15E-06
Fluorene	86737		1.17E-05	2.94E-06
Formaldehyde	50000		3.14E-01	7.88E-02
Naphthalene	91203		2.55E-03	6.41E-04
Phenanthrene	85018		7.11E-05	1.79E-05
Pyrene	129000		2.09E-05	5.25E-06

3.16.5 Emissions Estimates

Annual and seasonal emissions for each pollutant were calculated as:

tpy = F_C x E x (1 T/2000 lb)
tps = tpy x seasonal fraction from temporal profiles
where F_C is the amount of fuel used in the given county (Table 3-37)
E is the pollutant emission rate in the same units as F_C (Table 3-39)

3.17 Residential Wood Combustion

Residential wood combustion consists of home heating and recreational use of woodstoves, fireplaces, fireplace inserts, and pellet stoves. Other residential wood burning devices were not inventoried.

3.17.1 Activity Level

The measure of activity for residential wood combustion is the amount of wood burned. Residential wood combustion activity for each county was estimated using data from one of two residential wood combustion surveys. The first survey was conducted by Washington State University in 2001 (WSU2001).[76] It divided the state into regions and compiled results for each region. The WSU survey had 749 completed surveys for WA. The second survey was conducted by the National Research Center in 2007 (NRC2007).[77, 78] It covered seven geographic areas in

the central Puget Sound region and consisted of 1,015 completed surveys. Both surveys solicited complete information to conduct an inventory. The survey areas are shown below.

Table 3-40: Surveys and Survey Groups		
Survey	**Survey Group**	**Geographic Area**
NRC2007	PS_King	King County total
NRC2007	PS_Kit	Kitsap County total
NRC2007	PS_PieN	Pierce County Non-Urban Growth Area
NRC2007	PS_PieU	Pierce County Urban Growth Area
NRC2007	PS_SnoD	Snohomish County - Darrington
NRC2007	PS_SnoM	Snohomish County - Marysville, Lake Stevens, North Everett
NRC2007	PS_SnoO	Snohomish County - All other areas
WSU2001	Eastern WA_Range	Adams, Asotin, Benton, Franklin, Garfield, Grant, Lincoln, Whitman Counties

The surveys were compared. For all but the eastern WA rangeland counties, the two surveys were generally comparable. The NRC2007 survey was newer and included a higher concentration of survey responses, so it was used to characterize all counties except those classified as eastern WA rangeland. The WSU survey was used for the eastern WA rangeland counties. The survey assignments for each county group are shown below.

Table 3-41. County to Survey Assignments	
County(ies)	**Survey Group**
King	PS_King
Kitsap	PS_Kits
Pierce	Household weighted average of PS_PieN and PS_PieU
Snohomish	Household weighted average of PS_SnoD, PS_SnoM, and PS_SnoO
Adams, Asotin, Benton, Franklin, Garfield, Grant, Lincoln, Whitman	EWA_Range
All Other	Household weighted average of all the PS survey areas except King Co.*
* King County results would not be a good characterization of other counties since it contains the greater Seattle area and is much more urbanized than the rest of the state.	

The surveys were used to determine the percentage of households using wood burning devices, the fraction of certified stoves and inserts, and the annual amount of wood burned per device for fireplaces, woodstoves, inserts, and pellet stoves. Industry data was used to break out certified stoves and inserts into catalytic (25%) and non-catalytic (75%).

The fractions of households owning and using wood burning devices are shown in the tables below. Device ownership shown in Table 3-42 is for informative purposes only. The usage rates

in Table 3-43 are used in activity level calculations. The fraction of combined inserts and woodstoves that were in use and certified are shown in Table 3-44. Abbreviations used are: FP (fireplace), IN (insert), PS (pellet stove), and WS (woodstove).

Table 3-42. Device Ownership

Survey Group	FP	IN	PS	WS	Total
PS_King	0.318	0.086	0.020	0.071	0.475
PS_Kitsap	0.198	0.144	0.045	0.198	0.540
PS_Pierce	0.172	0.092	0.020	0.134	0.398
PS_Snohomish	0.183	0.132	0.043	0.134	0.450
PS_KitPieSno	0.180	0.115	0.033	0.143	0.439
CWA_Range	0.185	0.054	0.044	0.065	0.347

Table 3-43. Device Usage

Survey Group	FP	IN	PS	WS	Total
PS_King	0.173	0.059	0.016	0.059	0.290
PS_Kitsap	0.124	0.129	0.040	0.153	0.406
PS_Pierce	0.104	0.067	0.008	0.112	0.283
PS_Snohomish	0.117	0.080	0.038	0.124	0.321
PS_KitPieSno	0.112	0.081	0.025	0.123	0.316
CWA_Range	0.086	0.030	0.044	0.050	0.210

Table 3-44. Insert and Woodstove Certification

Survey Group	Certified	Not Certified
PS_King	0.42	0.58
PS_Kitsap	0.38	0.62
PS_Pierce	0.56	0.44
PS_Snohomish	0.52	0.48
PS_KitPieSno	0.52	0.48
CWA_Range	0.52	0.48

The surveys gathered information on the amount of pellets, firelogs, bundles of wood, pickup loads, and cord wood burned. To calculate emissions using emission factors in lb/ton burned, the weight of the wood burned was estimated. Pellets are sold in 40-lb sacks, and fire logs were estimated at 8 lb per log.

The weight of a cord of wood varies with moisture content and species type. The most common species reported in the survey were fir, alder, and maple. PSCAA estimated the bone dry (zero percent moisture) weight of a cord to be 2189 lb. This weight was used for all counties where the NRC2007 survey was used in order to keep the amount of wood burned consistent with the wood weight. For the areas using the WSU2001 survey, the dry weight was estimated at 2230 lb/cord. This was based on recommendations from staff at Ecology, the Department of Natural Resources (DNR), and the US Forest Service (USFS).[79, 80, 81]

Bundles of wood and the average of small and large pickup loads were assumed to be approximately 0.01563 cords and 0.3494 cords, respectively.[77]

Table 3-45. Type and Amount of Wood Burned Per Device

Fuel	Survey Group	FP	IN	PS	WS	ANY
Cords	PS_King	1.1	1.3	0.0	1.1	
	PS_Kitsap	0.9	1.5	0.0	1.6	
	PS_Pierce	0.9	1.7	0.0	1.4	
	PS_Snohomish	0.9	1.4	0.0	2.2	
	PS_KitPieSno	0.9	1.6	0.0	1.7	
	CWA_Range	0.7	1.3	0.0	1.4	
Pickups	PS_King	0.2	0.0	0.0	0.5	
	PS_Kitsap	0.1	0.1	0.0	0.9	
	PS_Pierce	0.0	0.0	0.0	0.0	
	PS_Snohomish	0.1	2.4	0.0	1.9	
	PS_KitPieSno	0.1	1.0	0.0	0.9	
	CWA_Range	0.0	0.0	0.0	0.0	
Bundles	PS_King	2.2	3.6	0.0	2.3	
	PS_Kitsap	3.3	2.4	0.0	1.9	
	PS_Pierce	1.3	0.2	0.0	1.1	
	PS_Snohomish	2.3	4.2	0.0	0.8	
	PS_KitPieSno	2.0	2.1	0.0	1.1	
	CWA_Range	0.0	0.0	0.0	0.0	
Firelogs	PS_King					3.8
	PS_Kitsap					5.2
	PS_Pierce					4.5
	PS_Snohomish					4.0
	PS_KitPieSno					4.4
	CWA_Range					2.5
Pellets	PS_King	0.0	0.0	34.3	0.0	
	PS_Kitsap	0.0	0.0	39.7	0.0	
	PS_Pierce	0.0	0.0	7.2	0.0	
	PS_Snohomish	0.0	0.0	44.5	0.0	
	PS_KitPieSno	0.0	0.0	26.7	0.0	
	CWA_Range	0.0	0.0	93.4	0.0	

Table 3-46. Wood Species Weight for CWA_Range		
Species	**Lb/Cord (Dry)**	**% Use EWA**
Douglas Fir	2,376	25
Larch	2,664	25
Lodgepole Pine	2,088	25
Ponderosa Pine	1,792	25
Weighted Avg	**2,230**	

Table 3-47. Dry (0% Moisture) Weight of Wood by Type and Survey Area in Pounds		
Fuel	**NRC2007**	**WSU2001**
Cords	2,189	2,230
Pickups	925	942
Bundles	34	35
Firelogs	8	8
Pellet	40	40

Table 3-48. Tons of Wood Burned by County and Device

County	Fireplaces	Inserts		Woodstoves		Pellet Stoves	Firelogs	TOTAL
		Uncert	Cert	Uncert	Cert			
Adams	400	115	125	211	229	471	12	**1,563**
Asotin	644	185	201	340	368	759	19	**2,518**
Benton	4,601	1,324	1,435	2,427	2,631	5,424	139	**17,980**
Chelan	3,184	2,364	2,563	3,795	4,114	340	156	**16,516**
Clallam	3,588	2,664	2,888	4,276	4,636	383	176	**18,612**
Clark	18,150	13,476	14,610	21,630	23,450	1,938	889	**94,143**
Columbia	202	150	163	241	261	22	10	**1,049**
Cowlitz	4,607	3,420	3,708	5,490	5,952	492	226	**23,895**
Douglas	1,594	1,184	1,283	1,900	2,060	170	78	**8,270**
Ferry	366	271	294	436	472	39	18	**1,896**
Franklin	1,641	472	512	866	939	1,935	50	**6,414**
Garfield	68	20	21	36	39	81	2	**267**
Grant	2,109	607	658	1,112	1,206	2,486	64	**8,241**
Grays Harbor	3,263	2,423	2,627	3,889	4,216	348	160	**16,925**
Island	3,756	2,789	3,024	4,476	4,853	401	184	**19,483**

Table 3-48. Tons of Wood Burned by County and Device								
County	Fireplaces	Inserts		Woodstoves		Pellet Stoves	Firelogs	TOTAL
		Uncert	Cert	Uncert	Cert			
Jefferson	1,615	1,199	1,300	1,925	2,087	172	79	**8,377**
King	184,431	38,963	27,831	39,313	28,081	9,688	3,484	**331,791**
Kitsap	13,414	13,502	8,380	20,232	12,558	1,191	824	**70,101**
Kittitas	1,912	1,420	1,539	2,279	2,470	204	94	**9,918**
Klickitat	961	714	774	1,146	1,242	103	47	**4,987**
Lewis	3,416	2,537	2,750	4,071	4,414	365	167	**17,720**
Lincoln	309	89	96	163	177	364	9	**1,207**
Mason	2,734	2,030	2,201	3,258	3,532	292	134	**14,181**
Okanogan	1,887	1,401	1,519	2,249	2,438	201	92	**9,787**
Pacific	1,084	805	872	1,291	1,400	116	53	**5,621**
Pend Oreille	626	465	504	746	809	67	31	**3,247**
Pierce	30,366	16,323	21,039	22,299	28,742	3,677	1,553	**124,000**
San Juan	877	651	706	1,045	1,133	94	43	**4,549**
Skagit	5,224	3,879	4,206	6,226	6,750	558	256	**27,099**
Skamania	520	386	418	619	672	56	25	**2,696**
Snohomish	33,058	28,244	30,590	52,749	57,130	3,290	1,391	**206,453**
Spokane	21,459	15,933	17,274	25,574	27,725	2,291	1,051	**111,307**
Stevens	1,983	1,473	1,597	2,364	2,562	212	97	**10,287**
Thurston	11,582	8,599	9,323	13,802	14,964	1,237	567	**60,074**
Wahkiakum	199	148	161	238	258	21	10	**1,034**
Walla Walla	2,489	1,848	2,003	2,966	3,216	266	122	**12,910**
Whatcom	9,215	6,842	7,418	10,982	11,906	984	451	**47,797**
Whitman	1,217	350	380	642	696	1,435	37	**4,758**
Yakima	9,254	6,871	7,449	11,029	11,957	988	453	**48,001**
STATE TOTAL	**388,006**	**186,136**	**184,442**	**278,331**	**282,342**	**43,163**	**13,255**	**1,375,675**

3.17.2 Emission Rates

Criteria and toxic pollutant emission factors in pounds of pollutant per ton of wood burned were taken from version 1 of EPA's 2011 Residential Wood Combustion tool. The emission rates are based on dry (0% moisture) wood. The weight of wood burned was expressed as 0% moisture so no adjustments were made prior to calculating emissions.

Table 3-49. Criteria Pollutant Emission Factors in Pounds Per Ton Burned							
Equipment Type	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**NO_X**	**VOC**	**CO**	**NH_3**
Fireplaces	23.6	23.6	0.4	2.6	18.9	149	1.8
Inserts & wood stoves, certified catalytic	20.4	20.4	0.4	2	15	104.4	0.9
Inserts & wood stoves, certified non-catalytic	19.6	19.6	0.4	2.28	12	140.8	0.9
Inserts & woodstoves, uncertified	30.6	30.6	0.4	2.8	53	230.8	1.7
Pellet stoves	3.06	3.06	0.32	3.8	0.041	15.9	0.3
Firelogs, all device types	29.32	28.4		7.684	39.56	125.08	

Table 3-50. Toxics Emission Factors in Pounds Per Tons Burned						
Pollutant	**FP**	**IN & WS Certified Catalytic**	**IN & WS Certified NonCat**	**IN & WS Un-certified**	**PS**	**Firelog**
1,2,3,4,6,7,8-Heptachlorodibenzofuran (67562394)	3.00E-10	3.00E-10	3.00E-10	3.00E-10		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-Dioxin (35822469)	3.16E-10	3.16E-10	3.16E-10	3.16E-10		
1,2,3,4,7,8,9-Heptachlorodibenzofuran (55673897)	2.34E-10	2.34E-10	2.34E-10	2.34E-10		
1,2,3,4,7,8-Hexachlorodibenzofuran (70648269)	3.56E-10	3.56E-10	3.56E-10	3.56E-10		
1,2,3,4,7,8-Hexachlorodibenzo-p-Dioxin (39227286)	2.50E-10	2.50E-10	2.50E-10	2.50E-10		
1,2,3,6,7,8-Hexachlorodibenzofuran (57117449)	2.20E-10	2.20E-10	2.20E-10	2.20E-10		
1,2,3,6,7,8-Hexachlorodibenzo-p-Dioxin (57653857)	2.50E-10	2.50E-10	2.50E-10	2.50E-10		
1,2,3,7,8,9-Hexachlorodibenzofuran (72918219)	1.98E-10	1.98E-10	1.98E-10	1.98E-10		
1,2,3,7,8,9-Hexachlorodibenzo-p-Dioxin (19408743)	2.50E-10	2.50E-10	2.50E-10	2.50E-10		
1,2,3,7,8-Pentachlorodibenzofuran (57117416)	4.56E-10	4.56E-10	4.56E-10	4.56E-10		
1,2,3,7,8-Pentachlorodibenzo-p-Dioxin (40321764)	2.58E-10	2.58E-10	2.58E-10	2.58E-10		
1,3-Butadiene (106990)	1.57E-01	1.95E-01	1.75E-01	3.90E-01	9.50E-04	
2,3,4,6,7,8-Hexachlorodibenzofuran (60851345)	1.65E-10	1.65E-10	1.65E-10	1.65E-10		
2,3,4,7,8-Pentachlorodibenzofuran (57117314)	6.44E-10	6.44E-10	6.44E-10	6.44E-10		
2,3,7,8-Tetrachlorodibenzofuran (51207319)	1.25E-09	1.25E-09	1.25E-09	1.25E-09		
2,3,7,8-Tetrachlorodibenzo-p-Dioxin (1746016)	2.28E-10	2.28E-10	2.28E-10	2.28E-10		
7,12-Dimethylbenz[a]Anthracene (57976)			1.62E-03			
Acenaphthene (83329)		3.08E-03	4.04E-03	6.21E-03		1.68E-03
Acenaphthylene (208968)		3.49E-02	1.29E-02	1.32E-01		7.48E-03
Acetaldehyde (75070)	1.07E+00	5.31E-01	6.32E-01	6.16E-01	9.40E-02	

Table 3-50. Toxics Emission Factors in Pounds Per Tons Burned						
Pollutant	**FP**	**IN & WS Certified Catalytic**	**IN & WS Certified NonCat**	**IN & WS Un-certified**	**PS**	**Firelog**
Acrolein (107028)	1.23E-01	3.14E-02	4.04E-02	9.10E-02	1.01E-02	
Anthracene (120127)		4.10E-03	3.64E-03	8.69E-03		2.32E-03
Benz[a]Anthracene (56553)		1.23E-02		1.24E-02		1.20E-03
Benzene (71432)	6.86E-01	1.46E+00	9.59E-01	1.94E+00	2.89E-02	1.07E+00
Benzo(g,h,i)Fluoranthene (203123)		3.08E-03	1.13E-02			
Benzo[a]Pyrene (50328)	1.00E-03	2.05E-03	2.42E-03	2.48E-03	6.70E-03	1.20E-03
Benzo[b]Fluoranthene (205992)		2.05E-03	1.62E-03	3.73E-03		1.12E-03
Benzo[e]Pyrene (192972)		2.05E-03	8.08E-04	7.45E-03		
Benzo[g,h,i,]Perylene (191242)		1.03E-03	8.08E-03	2.48E-03		6.80E-04
Benzo[k]Fluoranthene (207089)		1.03E-03		1.24E-03		6.00E-04
Biphenyl (92524)			8.89E-03			
Cadmium (7440439)			2.00E-05	2.20E-05		
Chrysene (218019)		5.13E-03	4.04E-03	7.45E-03	7.52E-05	1.88E-03
Cresols (Includes o, m, & p)/Cresylic Acids (1319773)	3.57E-01	5.31E-01	4.62E-01	1.60E-01	1.55E-02	
Dibenzo[a,h]Anthracene (53703)		1.03E-03	1.62E-03			6.00E-04
Dioxins/Furans as 2,3,7,8-TCDD TEQs - WHO2005 (628)	7.87E-10	2.28E-09	7.94E-10	4.60E-09	3.80E-09	
Fluoranthene (206440)		6.16E-03	3.23E-03	1.24E-02	5.48E-05	4.28E-03
Fluorene (86737)		7.18E-03	5.66E-03	1.49E-02		5.48E-03
Formaldehyde (50000)	1.79E+00	9.82E-01	2.22E+00	1.45E+00	3.16E-01	
Indeno[1,2,3-c,d]Pyrene (193395)		2.05E-03	8.08E-03			6.80E-04
Manganese (7439965)			1.40E-04	1.70E-04		
Mercury (7439976)	5.20E-06	5.20E-06	5.20E-06	5.20E-06	5.20E-06	
Naphthalene (91203)	2.65E-01	9.54E-02	5.82E-02	1.79E-01	4.23E-01	9.76E-02
Nickel (7440020)			2.00E-05	1.40E-05		
Octachlorodibenzofuran (39001020)	1.67E-10	1.67E-10	1.67E-10	1.67E-10		
Octachlorodibenzo-p-Dioxin (3268879)	6.66E-10	6.66E-10	6.66E-10	6.66E-10		
o-Xylene (95476)		1.86E-01		2.02E-01		
Perylene (198550)			8.08E-04			
Phenanthrene (85018)		2.46E-02	4.77E-02	4.84E-02	3.32E-05	1.72E-02
Phenol (108952)	4.72E-01	4.08E-01	4.87E-01	2.95E-01	2.50E-02	
Pyrene (129000)		5.13E-03	3.23E-03	1.49E-02	4.84E-05	4.24E-03
Toluene (108883)		5.20E-01		7.30E-01		

3.17.3 Spatial and Temporal Allocation

Spatial allocation was not necessary since occupied housing units were available by county.

Temporal allocation was based on a relationship between temperature and ambient fine particulate concentrations. Analysis of several $PM_{2.5}$ and meteorological monitoring sites showed a strong linear relationship between ambient temperature and ambient fine particulate concentrations at temperatures below 50 degrees Fahrenheit.[82] Heating degree days (based on 50 degrees = HDD_{50}) were calculated for each day during the NRC2007 survey period (Sept. 2006 - Aug. 2007).[83] The total seasonal HDD_{50} were divided by the annual HDD_{50} to estimate seasonal fractions.

It is recognized that temperatures vary across the state and seasonal patterns may not be the same everywhere. More precise seasonal breakouts may be calculated as needed for specific projects.

Table 3-51. Seasonal Activity Fractions, Residential Wood Combustion

Winter	Spring	Summer	Fall
0.68	0.13	0.00	0.20

3.17.4 Emissions Estimates

Annual and seasonal emissions for each wood burning device were calculated according to the following equations:

tpy = (HH) x (usage fraction) x (seasoned tons burned/device-yr) x
(0.8 T dry weight/1 T seasoned weight) x (pollutant lb /T dry weight) x (T/2000 lb)

tps = (tpy) x (seasonal fraction)

Annual emissions for each wood burning device were calculated according to the following equation:

tpy = (OHU) x (usage fraction) x (T burned/device-yr) x (pollutant lb/T) x (T/2000 lb)
where OHU= number of occupied housing units in the geographic area

tps = tpy x (seasonal fraction)

3.18 Agricultural Harvesting Operations

The Western Regional Air Partnership (WRAP) recently published a handbook for calculating dust emissions which included harvesting operations. Harvesting emissions are generated by three different operations: crop handling by the harvest machine, loading of the harvested crop into trailers or trucks, and transport by trailers or trucks in the field. Emissions from these operations are in the form of solid particulates composed mainly of raw plant material and soil dust that is entrained into the air."[84] The WRAP Handbook recommended the methodology and emission rates used by the California Air Resources Board (CARB).

3.18.1 Activity Level and Spatial Adjustments

Acres harvested by crop type are the measure of activity. The USDA and WSDA work together to publish agricultural area harvested statistics. Statistics for 2011 were available from USDA/WSDA for several major crop and fruit types. Every 5 years an extensive national census is made. The most recent was the 2007 Census of Agriculture. The USDA National Agricultural Statistics Service (NASS) published the USDA/WSDA crop data and Census data on-line for query and download.[85] USDA/WSDA fruit reports were published separately.[86, 87] The USDA/WSDA data included individual county acreage estimates for several crop types, and combined totals of two or more counties within an agricultural district where individual county acreage was considered confidential. The 2007 Census included more crop types than the USDA/WSDA data, and included individual county acres expressed as a range for some of the crops that were combined and presented only as district totals in the annual USDA/WSDA data.

The crop and fruit types reported in the USDA/WSDA 2011 data were the basis of the agricultural harvesting emissions. The 2007 Census data was used to apportion acreage to individual counties when the county estimates had been combined by USDA/WSDA as a total of two or more counties. To apportion the data, the following process was used:

1) Assign the midpoint of the acreage range assigned to each district, county, crop, and range combination.
2) Multiply the number of operations by the midpoint assigned above for each district, county, crop, and range combination.
3) Sum the total acres calculated in (2) above by district, county, and crop.
4) Sum the total acres calculated in (2) above by district and crop.
5) Divide the acres calculated in (3) by the acres in (4) to obtain the county, and crop fraction of the total combined acreage from USDA/WSDA.
6) Multiply the fractions in (5) by the total combined acreage from USDA/WSDA to estimate county acreage.

Harvested acreage by county is shown in Table 3-52. Similar crop types were grouped.

Table 3-52. Harvested Acres by County

County	Beans, Dry	Corn, Grain	Fruit Trees & Grapes	Grains	Hay	Potatoes
Adams	7,200		3,747	290,300	19,000	
Asotin	3,300			22,000	2,000	
Benton			35,440	92,300	10,000	
Chelan		15,000	21,299			
Clallam					3,000	
Clark			62	1,350	19,300	
Columbia	3,300	4,100		99,600	3,000	

Table 3-52. Harvested Acres by County						
County	**Beans, Dry**	**Corn, Grain**	**Fruit Trees & Grapes**	**Grains**	**Hay**	**Potatoes**
Cowlitz					5,000	
Douglas		13,100	14,551	151,000	3,500	
Ferry					4,000	
Franklin	800	23,200	20,691	64,500	70,000	
Garfield				57,500	2,500	
Grant	9,500	56,000	59,561	157,300	119,500	43,000
Grays Harbor					9,000	
Island			17	600	4,100	
Jefferson					2,200	
King					4,000	
Kitsap				1,350	1,000	
Kittitas		15,000	17	600	56,000	
Klickitat			9,203	51,850	35,000	
Lewis					34,000	
Lincoln	1,500			400,300	13,000	
Mason					4,000	
Okanogan		15,000	24,976	12,350	38,000	
Pacific					5,500	
Pend Oreille				20,600	15,000	
Pierce					4,500	
San Juan			14	1,350	3,500	
Skagit			36	3,350	24,800	9,500
Skamania			195		1,100	
Snohomish					14,200	
Spokane			8	97,000	50,000	
Stevens			11		24,000	
Thurston				1,350	9,000	
Wahkiakum					2,000	
Walla Walla	6,500		9,807	209,700	13,000	
Whatcom				1,350	19,000	
Whitman	45,200	4,100		551,200	13,500	
Yakima		11,400	74,616	28,200	34,000	
State Total	**77,300**	**156,900**	**274,251**	**2,317,000**	**694,200**	**52,500**

3.18.2 Temporal Adjustments

WSDA and USDA publish usual planting and harvesting dates for Washington.[88, 89] Each month is divided into three trimesters and one of three activity classes is assigned to each: none,

starting/ending, and most active. This information was used to calculate seasonal activity fractions for each crop type by assigning each activity class a numerical value and using the following equation:

crop season fraction = Σ(crop seasonal trimester values) / Σ(crop annual trimester values)
where trimester values are 0.0 for none
0.5 for starting/ending
1.0 for most active

The USDA dates were preferentially used since the USDA information was more recent. However, the USDA information only had 11 crop types. The WSDA information included more crop types and was used when there were no USDA dates. Dates from a similar crop were assigned to a crop with no given dates.

3.18.3 Emission Rates

Emission rates were taken from the WRAP Handbook. The handbook assumed that $PM_{2.5}$ was 15% of the PM_{10}. No control measures were assumed.

Table 3-53. Harvesting Emission Rates (lb/acre)

Crop	PM_{10}	$PM_{2.5}$
Apples	0.08	0.012
Apricots	0.08	0.012
Barley	5.8	0.87
Beans, Dry Edible	1.68	0.252
Corn, Grain	1.68	0.252
Grapes	0.17	0.0255
Hay, Alfalfa	0	0
Hay, Ex. Alfalfa	1.68	0.252
Nectarines	0.08	0.012
Peaches	0.08	0.012
Pears, Bartlett	0.08	0.012
Pears, Winter	0.08	0.012
Potatoes	1.68	0.252
Prunes and Plums	0.08	0.012
Sweet Cherries	0.08	0.012
Tart Cherries	0.08	0.012
Wheat, Spring, ex. Duram	5.8	0.87
Wheat, Winter	5.8	0.87

3.18.4 Emissions Estimates

Annual county emissions estimates of agricultural harvesting were calculated by multiplying the emission rates by the number of harvested acres by crop type. Seasonal county emissions estimates were calculated by multiplying annual emissions by the crop seasonal activity fraction.

tpy = (acres) x (lb pollutant/acre) x (1 T/2000 lb)
tps = tpy x seasonal fraction

3.19 Dairy and Beef Cattle Waste

Ammonia emissions from dairy and beef cattle manure were estimated using local cattle population data and emission factors from the Carnegie Mellon University (CMU) Ammonia Model v.3.6. Ecology sponsored research by an intern from WSU in the summer of 2013. Part of that research involved evaluating tools and methods for calculating ammonia emissions from livestock, which was used in developing this inventory.[90]

3.19.1 Activity Level

The Washington State Department of Agriculture (WSDA) and US Department of Agriculture (USDA) published information about the number of head of dairy cattle and total cattle by county.[91, 92] The dairy and total cattle counts were 2012 statistics. Beef cattle numbers were calculated by subtracting dairy cattle from total cattle counts.

Table 3-54. Cattle Population

County	Beef	Dairy		County	Beef	Dairy
Adams	26,454	18,046		Lewis	16,823	10,177
Asotin	8,800	0		Lincoln	16,762	438
Benton	31,893	8,107		Mason	2,000	0
Chelan	2,797	3		Okanogan	45,500	0
Clallam	5,284	916		Pacific	7,181	2,019
Clark	10,799	5,301		Pend Oreille	4,700	0
Columbia	5,900	0		Pierce	9,022	1,178
Cowlitz	3,490	1,010		San Juan	2,492	8
Douglas	11,300	0		Skagit	20,956	16,544
Ferry	4,200	0		Skamania	500	0
Franklin	22,615	36,385		Snohomish	24,060	13,940
Garfield	7,200	0		Spokane	21,370	1,630
Grant	119,519	50,481		Stevens	22,274	1,226
Grays Harbor	5,538	3,262		Thurston	11,196	6,404
Island	6,200	900		Wahkiakum	2,472	628
Jefferson	1,485	215		Walla Walla	44,000	0
King	13,055	11,945		Whatcom	28,575	68,425
Kitsap	1,480	20		Whitman	15,021	379

Table 3-54. Cattle Population						
~~County~~	Beef	Dairy		County	Beef	Dairy
Kittitas	28,745	255		Yakima	64,827	150,173
Klickitat	21,753	1,747		**STATE TOTAL**	**698,238**	**411,762**

The CMU model uses the term manure management train (MMT) to describe the flow of animal waste from excretion to application to the land within a certain manure management practice. Within the model development, animal numbers are split into different MMT. For dairy cattle, the MMTs were split among dry lot, scrape barn, flush, and deep pit. There was no discernible variation in the model data for dairies among WA counties. For beef cattle, the MMTs were divided between pasture and dry lot. Each county had a unique split for beef cattle. The percentage of cattle in each MMT is shown in the tables below.

Table 3-55. Dairy Cattle Manure Management Trains	
MMT	Percentage
Dry lot	54.0%
Scrape barn	30.5%
Flush	14.5%
Deep pit	1.0%

Table 3-56. Beef Cattle Manure Management Trains						
~~County~~	Dry lot	Pasture		County	Dry lot	Pasture
Adams	19.8	80.2		Lewis	6.0	94.0
Asotin	58.1	41.9		Lincoln	2.3	97.7
Benton	23.5	76.5		Mason	2.7	97.3
Chelan	1.6	98.4		Okanogan	4.6	95.4
Clallam	2.9	97.1		Pacific	1.2	98.8
Clark	19.3	80.7		Pend Oreille	0.9	99.1
Columbia	0.2	99.8		Pierce	13.5	86.5
Cowlitz	1.1	98.9		San Juan	1.3	98.7
Douglas	54.2	45.8		Skagit	3.6	96.4
Ferry	0.1	99.9		Skamania	5.3	94.7
Franklin	30.0	70.0		Snohomish	2.6	97.4
Garfield	55.2	44.8		Spokane	3.2	96.8
Grant	69.8	30.2		Stevens	1.3	98.7
Grays Harbor	2.3	97.7		Thurston	2.4	97.6
Island	1.7	98.3		Wahkiakum	100.0	0.0

Table 3-56. Beef Cattle Manure Management Trains						
County	Dry lot	Pasture		County	Dry lot	Pasture
Jefferson	4.6	95.4		Walla Walla	25.4	74.6
King	6.1	93.9		Whatcom	3.1	96.9
Kitsap	0.4	99.6		Whitman	2.0	98.0
Kittitas	2.7	97.3		Yakima	50.6	49.4
Klickitat	3.3	96.7				

3.19.2 Temporal and Spatial Adjustments

Spatial adjustments were not necessary since the information was available by county. A monthly allocation profile for dairy cattle in Washington was used for both dairy and beef. The profile was used in EPA's Clean Air Interstate Rule modeling platform. It allocates 13% of emissions to winter, 33% spring, 27% summer, and 28% fall.

WSU researchers measured ammonia during different meteorological conditions at the Knott Dairy farm.[93] , precipitation, and wind speed influenced results. This could be explored further in future inventory efforts, especially if the inventory is used for air quality modeling.

3.19.3 Emission Rates

Emission factors were taken from the CMU model. Each MMT, except the beef cattle pasture MMT, has emissions from three separate processes: confinement, land application, and storage and treatment. The emission factors were the same for all counties. Confinement is the only process for the beef cattle pasture MMT, .and varied by county. The reason for the variation was not researched.

Table 3-57. Livestock Emission Factors			
Cattle Type	MMT	Process	kg NH_3/ Head-Month
Dairy	Deep pit	Confinement	2.42
		Land Application	1.28
		Storage	0.113
	Dry lot	Confinement	0.68
		Land Application	0.718
		Storage	0.0249
	Flush	Confinement	2
		Land Application	0.491
		Storage	5.59
	Scrape	Confinement	0.718
		Land Application	1.21
		Storage	2.38
Beef	Dry lot	Confinement	0.945
		Land Application	0.794
		Storage	0.000378
	Pasture	Confinement	0.189 to 0.416

3.19.4 Emissions Estimates

Annual county emissions estimates were calculated by multiplying the emission rates by the number of head for each animal type. Seasonal county emissions estimates were calculated by multiplying the seasonal fractions by the annual emissions.

tpy = (#head) x (kg NH_3/head-mo) x (12 mos/yr) x (1.1023 x 10^{-3} T/kg)
tps = tpy x seasonal fraction

3.20 Fertilizer Application

Nitrogen fertilizers are widely used in Washington. Most of the nitrogen fertilizers can decompose and release ammonia after they are applied to croplands. Ammonia emissions from fertilizer application were estimated using methodology and emission factors from a Sonoma Technology, Inc (STI) study done for the Lake Michigan Air Directors Consortium (LADCO) which compared factors to an earlier study done for EPA.[94, 95] The emission factors were incorporated into the Carnegie Mellon University Ammonia Model version 3.6.

3.20.1 Activity Level

Local fertilizer tonnage was used for estimating activity. The amount of fertilizer purchased in Washington was available from the Dept. of Agriculture for individual fertilizer types.[96, 97] Amounts are shown in Table 3-59.

3.20.2 Temporal Adjustments

EPA developed a temporal profile for fertilizer application in Washington state for the Clean Air Interstate Rule.[98] The profile was used to allocate emissions to each season: winter 4%, spring 31%, summer 28%, and fall 37%.

3.20.3 Spatial Adjustments

The fertilizer use information was only available at the state level. Emissions were allocated to counties using the distribution in the preliminary 2011 default EPA inventory. The county fractions are shown in the table below.

Table 3-58. EPA Default Inventory County Fertilizer Emissions Distribution

County	Fraction		County	Fraction
Adams	0.11		Lewis	0.01
Asotin	0.01		Lincoln	0.10
Benton	0.06		Mason	0.00
Chelan	0.01		Okanogan	0.02
Clallam	0.00		Pacific	0.00
Clark	0.00		Pend Oreille	0.00
Columbia	0.02		Pierce	0.00
Cowlitz	0.00		San Juan	0.00

Table 3-58. EPA Default Inventory County Fertilizer Emissions Distribution				
County	**Fraction**		**County**	**Fraction**
Douglas	0.07		Skagit	0.01
Ferry	0.00		Skamania	0.00
Franklin	0.06		Snohomish	0.00
Garfield	0.02		Spokane	0.05
Grant	0.10		Stevens	0.01
Grays Harbor	0.00		Thurston	0.00
Island	0.00		Wahkiakum	0.00
Jefferson	0.00		Walla Walla	0.07
King	0.00		Whatcom	0.01
Kitsap	0.00		Whitman	0.14
Kittitas	0.01		Yakima	0.05
Klickitat	0.03		**State Total**	**1.00**

3.20.4 Emission Rates

Emission rates are shown in Table 3-59. Chemical composition and/or percent nitrogen content of the fertilizers was obtained from chemical references, which allowed calculation of nitrogen content.[99, 100, 101] The "other" category emissions were calculated by assuming the average emission rate per ton of fertilizer for all the nitrogen fertilizer types. Ammonia emission rates in (kg NH_3/1000 kg N) were taken from the STI report as included in the CMU Ammonia Model v3.6.[94] The report recommended using ammonia emission rates developed by the European Environment Agency (EEA 2001) since they were the only factors that accounted for differences associated with fertilizer type, soil type, and climate. They also were more representative of annual averages than some of the other available emission rates. EEA developed factors for three major groupings. The group II factors were chosen based on climate. This was a change from the 2005 inventory, where Group III factors were used. It is not certain whether Group II or Group III better represents Washington, but the EPA inventory and the CMU Ammonia Model used the Group II factors.

Table 3-59. Fertilizer Applied and Ammonia Released						
Fertilizer Name	**Tons Fertilizer**	**Formula**	**Tons N**	**%N**	**kg NH_3/ 1000 kg N**	**Tons NH_3**
ammonia, anhydrous	61,687	NH_3	50,801	82	40	2,032
ammonia, aqua	108,504	NH40H	21,701	20	40	868
ammonium nitrate	1,193	NH4NO3	417	35	20	8
ammonium polysulfide	1,538	(20% N)	308	20	100	31
ammonium sulfate	37,471	(NH4)2SO4	7,948	21	100	795
ammonium thiosulfate	36,647	(NH4)2S2O3	4,398	12	25	110

Table 3-59. Fertilizer Applied and Ammonia Released						
Fertilizer Name	**Tons Fertilizer**	**Formula**	**Tons N**	**%N**	**kg NH_3/ 1000 kg N**	**Tons NH_3**
calcium nitrate	7,953	$Ca(NO_3)_2$	1,358	17	20	27
nitrogen solution < 28% N	1,895	(28% N)	531	28	80	42
nitrogen solution < 32% N	137,581	(32% N)	44,026	32	80	3,522
Urea	102,713	$CO(NH_2)_2$	47,933	47	150	7,190
ammonia nit-sulfate[1]	0					
ammonium nitrate	0	NH_4NO_3	0		20	0
ammonium sulfate	0	$(NH_4)_2SO_4$	0		100	0
calcium ammonium nitrate[2]	8,147					
ammonium nitrate	4,888	NH_4NO_3	1,711	35	20	34
ammonium metaphosphate	0		0		50	0
diammonium phosphate	168	$(NH_4)_2HPO_4$	36	21	50	2
ammonium polyphosphate	0		0		50	0
monoammonium phosphate	33,296	$NH_4H_2PO_4$	4,053	12	50	203
liquid amm polyphosphate	30,560	$(NH_4)_3P_2O_7$	3,056	10	50	153
ammonium phos sulfate[3]	9,904					
ammonium nitrate	1,981	NH_4NO_3	693	35	20	14
monoammonium phosphate	7,923	$NH_4H_2PO_4$	965	12	50	48
Other	79,352		0	0	0	2,352
Total	**673,398**		**189,934**			**17,431**

[1] ammonium nitrate (40%), ammonium sulfate (60%)
[2] ammonium nitrate (60%), limestone/dolomite (40%)
[3] ammonium nitrate (20%), monoammonium phosphate (80%)

3.20.5 Emissions Estimates

Annual county emissions estimates were calculated by multiplying the annual statewide NH_3 emissions by the county fractions of emissions in the EPA default inventory (Table 3-58). Seasonal county emissions estimates were calculated using the seasonal fractions listed above.

tpy = (17,431 tons NH_3) x (county fraction of the default inventory emissions)
tps = tpy * seasonal fraction

3.21 Structure Fires

Emissions from accidental structure fires resulting from unintentional actions, arson, or natural events were estimated. Structure fire emissions were estimated using methods in the EIIP.[102]

3.21.1 Activity Level

National structure fire records are maintained by the Department of Homeland Security US Fire Administration. Records are kept on the National Fire Incident Reporting System (NFIRS).[103] Structure fire data was taken from the NFIRS database by county.

Table 3-60. Structure Fires

County	Fires		County	Fires
Adams	21		Lewis	231
Asotin	19		Lincoln	13
Benton	437		Mason	167
Chelan	133		Okanogan	79
Clallam	56		Pacific	78
Clark	399		Pend Oreille	15
Columbia	7		Pierce	1,114
Cowlitz	209		San Juan	31
Douglas	65		Skagit	285
Ferry	2		Skamania	2
Franklin	127		Snohomish	769
Garfield	6		Spokane	556
Grant	101		Stevens	65
Grays Harbor	162		Thurston	392
Island	129		Wahkiakum	8
Jefferson	106		Walla Walla	92
King	2,180		Whatcom	282
Kitsap	335		Whitman	53
Kittitas	51		Yakima	565
Klickitat	47		**State**	**9,389**

3.21.2 Temporal Adjustments

The EIIP provided monthly activity percentages for residential and non-residential fires. The percentages were weighed according to the total fires in each category. The resulting season distribution was 30% winter, 25% spring, 23% summer and 22% fall.

3.21.3 Spatial Adjustments

No spatial adjustment was necessary as the data in the NFIRS database was provided by county.

3.21.4 Emission Rates

The EIIP provided loading and emission factors. The loading factor was 1.15 tons consumed per fire. Emission factors are shown below. PM_{10} and $PM_{2.5}$ were estimated from total PM factors using California size fractions for unplanned structure fires (profile 137).[56]

Table 3-61. Structure Fire Emission Rates		
Pollutant	**Pollutant Code**	**lb/T**
Acrolein	107028	4.41
CO	CO	60
Formaldehyde	50000	1.02
Hydrochloric acid	7647010	15.11
Hydrogen cyanide	74908	35.49
NO_X	NO_X	1.4
PM	PM	10.8
PM_{10}	PM_{10}	10.6
$PM_{2.5}$	$PM_{2.5}$	9.9
VOC	VOC	11

3.21.5 Emissions Estimates

Annual county emissions estimates were calculated by multiplying the emission rates by the number of fires and loading per fire. Seasonal county emissions estimates were calculated using the seasonal percentages above.

tpy = (#fires) x (1.15 T/fire) x (emission rate in lb/T) x (1 T/2000 lb)
tps = (#fires) x (1.15 T/fire) x (emission rate in lb/T) x (seasonal fraction) x (1 T/2000 lb)
where: tpy = tons per year, tps = tons per season

3.22 Vehicle Fires

Emissions from accidental vehicle fires were estimated. Vehicle fires include any commercial or private vehicles authorized for use on public roads. Vehicle fire emissions were estimated using methods in the EIIP.[104]

3.22.1 Activity Level

National vehicle fire records are maintained by the Department of Homeland Security US Fire Administration in the NFIRS database. Vehicle fire data was taken from the NFIRS database by county and is in the table below.

Table 3-62. Vehicle Fires				
County	**Fires**		**County**	**Fires**
Adams	16		Lewis	65
Asotin	1		Lincoln	1
Benton	113		Mason	47
Chelan	35		Okanogan	32
Clallam	11		Pacific	10
Clark	129		Pend Oreille	4
Columbia	3		Pierce	328

Table 3-62. Vehicle Fires				
County	**Fires**		**County**	**Fires**
Cowlitz	72		San Juan	5
Douglas	20		Skagit	84
Ferry	1		Skamania	0
Franklin	47		Snohomish	240
Garfield	7		Spokane	238
Grant	62		Stevens	19
Grays Harbor	33		Thurston	87
Island	37		Wahkiakum	1
Jefferson	29		Walla Walla	37
King	872		Whatcom	73
Kitsap	115		Whitman	14
Kittitas	26		Yakima	193
Klickitat	12		**State**	**3119**

3.22.2 Temporal and Spatial Adjustments

Fires were assumed to occur uniformly throughout the year. No further spatial adjustments were necessary as the data from NFIRS was reported by county.

3.22.3 Emission Rates

The EIIP provided loading and emission factors. The loading factor was 500 lb consumed per fire. Emission factors are shown below. PM_{10} and $PM_{2.5}$ were estimated from total PM factors using California size fractions for unplanned structure fires (profile 137).[56]

Table 3-63. Vehicle Fire Emission Rates		
Pollutant	**Pollutant Code**	**Lb/T**
CO	CO	125
Nonmethane TOC	VOC	32
NO_X	NO_X	4
PM	PM	100
PM_{10}	PM_{10}	98
$PM_{2.5}$	$PM_{2.5}$	91

3.22.4 Emissions Estimates

Annual county emissions estimates were calculated by multiplying the emission rates by the number of fires and loading per fire. Seasonal county emissions estimates were calculated by assuming uniform operation throughout the year, a 25% seasonal fraction.

tpy = (#fires) x (0.25 T/fire) x (emission rate in lb/T) x (1 T/2000 lb)
tps = (#fires) x (0.25 T/fire) x (emission rate in lb/T) x (seasonal fraction) x (1 T/2000 lb)
where: tpy = tons per year, tps = tons per season

3.23 Categories Accepted from EPA

EPA estimated several categories in addition to those listed in this document. Washington accepted the EPA estimates for categories not estimated by Washington ECY and included them in the Washington state emissions inventory.

3.23.1 Wildfires

EPA has created a new category, EVENT, within the NEI for wildfires and prescribed burning, Washington did not have wildfire data so the EPA estimates were accepted for wildfires.

Wildfire emissions reported in the 2011 EPA NEI were generated by Sonoma Technology Incorporated (STI). STI utilized the Satellite Mapping Automatic Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) v2 to determine fire location and size, the Wildland Fire Assessment System (WFAS) National Fuel Moisture Database (NFDM) to estimate fuel moisture, and the BlueSky modeling framework to estimate the resultant emissions. This effort used SMARTFIRE v2 to combine fire locations reported by the following sources: Incident Command Summary (ICS-209) reports, the National Oceanic and Atmospheric Administration (NOAA) Hazard Mapping System (HMS), fire perimeters from the Geospatial Multi-Agency Coordination (GeoMAC) group, the Western Regional Alliance Program (WRAP) Fire Emissions Tracking System (FETS), the National Association of State Foresters (NASF) fire database, the US Forest Service ACtivity Tracking System (FACTS), and the US Fish and Wildlife prescribed burn database.

3.23.1.1 Activity Level

The county level estimate of wildfire area burned that was reported by the EPA is shown in the table below.

Table 3-64. EPA Reported Wildfire Area Burned by County

County	Acres		County	Acres
Adams	1600.1		Lewis	1.7
Asotin	0.0		Lincoln	3402.3
Benton	1171.3		Mason	103.3
Chelan	778.4		Okanogan	10093.2
Clallam	178.5		Pacific	0.5

Table 3-64. EPA Reported Wildfire Area Burned by County				
County	**Acres**		**County**	**Acres**
Clark	1.6		Pend Oreille	63.4
Columbia	0.3		Pierce	861.9
Cowlitz	105.6		San Juan	0.6
Douglas	1800.0		Skagit	19.7
Ferry	436.0		Skamania	49.0
Franklin	4300.0		Snohomish	47.1
Garfield	4148.2		Spokane	248.5
Grant	1500.5		Stevens	350.4
Grays Harbor	288.9		Thurston	349.6
Island	0.0		Wahkiakum	0.1
Jefferson	1253.7		Walla Walla	18381.8
King	22.5		Whatcom	0.1
Kitsap	0		Whitman	0.0
Kittitas	2354.7		Yakima	3052.2
Klickitat	23144.7		**State**	**80,110**

3.23.1.2 Emissions Estimates

The BlueSky modeling framework incorporates a variety of modeling components to determine emissions. This effort simulated emissions in BlueSky using the following model pathway: the Landscape Fire and Resource Management Planning Tools (LANDFIRE) Fuel Characteristic Classification System (FCCS) to determine fuel loading, the Consume model to estimate the percentage of fuels consumed, and the Fire Emission Production Simulator (FEPS) to estimate total emissions by pollutant type.

3.23.2 Other Accepted Categories

Several other categories in addition to wildfires were accepted from EPA and are listed in Table 3-65. Please refer to the technical support document for EPA 2011 Comprehensive Emission inventory which is currently in draft format and may not contain complete information for each category.[105] The accepted data was downloaded for annual emissions, except for biogenic emissions which were seasonal. The table below lists all the categories that were accepted and the temporal emission fractions applied to them for each season. The temporal allocation factors were taken from the AIRPACT temporal emission profiles.

Table 3-65. EPA Categories Accepted by Ecology and Seasonal Allocation Fractions				
Category	**Winter**	**Spring**	**Summer**	**Fall**
Stationary Fuel Comb /Commercial/Institutional /Wood	0.35	0.25	0.15	0.25
Stationary Fuel Comb /Residential /Kerosene	0.57	0.22	0.01	0.19
Aircraft /Military Aircraft /Total	0.25	0.25	0.25	0.25
Aircraft /Commercial Aircraft /Total: All Types	0.25	0.25	0.25	0.25
Aircraft /General Aviation /Piston	0.25	0.25	0.25	0.25
Aircraft /General Aviation /Turbine	0.25	0.25	0.25	0.25
Aircraft /Air Taxi /Piston	0.25	0.25	0.25	0.25
Aircraft /Air Taxi /Turbine	0.25	0.25	0.25	0.25
Aircraft /In-flight	0.25	0.25	0.25	0.25
Marine Vessels, Commercial /Diesel /Port emissions	0.25	0.25	0.25	0.25
Marine Vessels, Commercial /Diesel /Underway emissions	0.25	0.25	0.25	0.25
Marine Vessels, Commercial /Residual /Port emissions	0.25	0.25	0.25	0.25
Marine Vessels, Commercial /Residual /Underway emissions	0.25	0.25	0.25	0.25
Railroad Equipment /Diesel /Line Haul Locomotives: Class II / III Operations	0.25	0.25	0.25	0.25
Food & Kindred Products /Commercial Cooking - Charbroiling /Conveyorized Charbroiling	0.25	0.25	0.25	0.25
Food & Kindred Products /Commercial Cooking - Charbroiling /Under-fired Charbroiling	0.25	0.25	0.25	0.25
Food & Kindred Products /Commercial Cooking - Frying /Deep Fat Fying	0.25	0.25	0.25	0.25
Food & Kindred Products /Commercial Cooking - Frying /Flat Griddle Frying	0.25	0.25	0.25	0.25
Food & Kindred Products /Commercial Cooking - Frying /Clamshell Griddle Frying	0.25	0.25	0.25	0.25
Construction: SIC 15 - 17 /Residential /Total	0.25	0.25	0.25	0.25
Construction: SIC 15 - 17 /Industrial/Commercial/Institutional /Total	0.25	0.25	0.25	0.25
Construction: SIC 15 - 17 /Road Construction /Total	0.25	0.25	0.25	0.25
Mining &Quarrying /All Processes /Total	0.25	0.25	0.25	0.25
Surface Coating /Railroad /Total: All Solvent Types	0.24	0.24	0.26	0.26
Misc Non-industrial: Commercial /Cutback Asphalt	0.25	0.25	0.25	0.25
Misc Non-industrial: Commercial /Emulsified Asphalt	0.25	0.25	0.25	0.25
Misc Non-industrial: Commercial /Pesticide Application: Agricultural /All Processes	0.25	0.25	0.25	0.25
Residential Portable Gas Cans /Permeation	0.25	0.25	0.25	0.25
Residential Portable Gas Cans /Evaporation (includes Diurnal losses)	0.25	0.25	0.25	0.25
Residential Portable Gas Cans /Spillage During Transport	0.23	0.25	0.27	0.25
Residential Portable Gas Cans /Refilling at the Pump - Vapor Displacement	0.25	0.25	0.25	0.25
Residential Portable Gas Cans /Refilling at the Pump - Spillage	0.25	0.25	0.25	0.25
Commercial Portable Gas Cans /Permeation	0.25	0.25	0.25	0.25
Commercial Portable Gas Cans /Evaporation (includes Diurnal losses)	0.25	0.25	0.25	0.25
Commercial Portable Gas Cans /Spillage During Transport	0.23	0.25	0.27	0.25

Table 3-65. EPA Categories Accepted by Ecology and Seasonal Allocation Fractions				
Category	**Winter**	**Spring**	**Summer**	**Fall**
Commercial Portable Gas Cans /Refilling at the Pump - Vapor Displacement	0.25	0.25	0.25	0.25
Commercial Portable Gas Cans /Refilling at the Pump - Spillage	0.25	0.25	0.25	0.25
Petrol & Petrol Product Storage /Bulk Terminals: All Evaporative Losses /Gasoline	0.25	0.25	0.25	0.25
Petrol & Petrol Product Storage /Bulk Plants: All Evaporative Losses /Gasoline	0.25	0.25	0.25	0.25
Diesel Service Stations /Stage 2: Total	0.23	0.25	0.27	0.25
Petrol & Petrol Product Storage /Airports : Aviation Gasoline /Stage 1: Total	0.25	0.25	0.25	0.25
Petrol & Petrol Product Storage /Airports : Aviation Gasoline /Stage 2: Total	0.25	0.25	0.25	0.25
Petrol & Petrol Product Transport /Pipeline /Gasoline	0.25	0.25	0.25	0.25
Agric - Crops /Tilling	0.32	0.43	0.00	0.25
Agric - Livestock /Poultry production - layers with dry manure management systems /Confinement	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - layers with dry manure management systems /Land application of manure	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - layers with wet manure management systems /Confinement	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - layers with wet manure management systems /Manure handling & storage	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - layers with wet manure management systems /Land application of manure	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - broilers /Confinement	0.25	0.25	0.25	0.25
Agric - Livestock /Poultry production - broilers /Manure handling and storage	0.25	0.25	0.25	0.25
Agric - Livestock /Poultry production - broilers /Land application of manure	0.25	0.25	0.25	0.25
Agric - Livestock /Poultry production - turkeys /Confinement	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - turkeys /Manure handling and storage	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry production - turkeys /Land application of manure	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry Waste Emissions /Not Elsewhere Classified	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry Waste Emissions /Ducks	0.18	0.25	0.34	0.23
Agric - Livestock /Poultry Waste Emissions /Geese	0.18	0.25	0.34	0.23
Agric - Livestock /Horses & Ponies Waste Emissions /Not Elsewhere Classified	0.18	0.25	0.34	0.23
Agric - Livestock /Swine production - operations with lagoons (unspecified animal age) /Confinement	0.18	0.25	0.34	0.23
Agric - Livestock /Swine production - operations with lagoons (unspecified animal age) /Manure handling & storage	0.18	0.25	0.34	0.23
Agric - Livestock /Swine production - operations with lagoons (unspecified animal age) /Land application of manure	0.18	0.25	0.34	0.23
Agric - Livestock /Sheep & Lambs Waste Emissions /Total	0.18	0.25	0.34	0.23
Agric - Livestock /Goats Waste Emissions /Not Elsewhere Classified	0.18	0.25	0.34	0.23
Agric - Livestock /Swine production - deep-pit house operations	0.18	0.25	0.34	0.23

Table 3-65. EPA Categories Accepted by Ecology and Seasonal Allocation Fractions				
Category	**Winter**	**Spring**	**Summer**	**Fall**
(unspecified animal age) /Confinement				
Agric - Livestock /Swine production - deep-pit house operations (unspecified animal age) /Land application of manure	0.18	0.25	0.34	0.23
Agric - Livestock /Swine production - outdoor operations (unspecified animal age) /Confinement	0.18	0.25	0.34	0.23
Forest Wildfires - Wildfires - Unspecified	0.00	0.03	0.89	0.08
Cremation /Humans	0.25	0.25	0.25	0.25
Health Services /Dental Alloy Production /Overall Process	0.25	0.25	0.25	0.25
Laboratories /Bench Scale Reagents	0.25	0.25	0.25	0.25
Fluorescent Lamp Breakage /Non-recycling Related Emissions	0.25	0.25	0.25	0.25
Fluorescent Lamp Breakage /Recycling Related Emissions	0.25	0.25	0.25	0.25

4 Emissions Summaries

Annual emissions summaries are presented for criteria pollutants, ammonia, and diesel fine particulate matter ($DSPM_{2.5}$). Neither seasonal nor toxics (except $DSPM_{2.5}$) emissions are shown here, but they can be generated from the emissions inventory database. More detailed category breakouts can also be generated. Abbreviations used are shown below.

AIR	Aircraft: military, commercial, general aviation
BOAT	Recreational boats
CONS	Commercial and consumer solvents
CONST	Construction
F_COMM	Commercial fuel use: natural gas, oil, LPG
F_RES	Residential fuel use: natural gas, oil, LPG
FERT	Fertilizer application
FIRE	Wildfires
FOOD	Food and Kindred Products
GAS_TRANS	Aviation gas storage and transport, petroleum gas cans, bulk plants, and truck transport
GASSTN	Gasoline stations
LIVE	Livestock wastes
MISC	Structure and motor vehicle fires, Cremation, Dental alloy production, Bench scale reagents, Fluorescent lamps
NAT	Natural emissions from soil and vegetation
NRM	Nonroad mobile except locomotives
OB_nonRES	Agricultural and silvicultural burning
OB_Res	Residential outdoor burning: yard waste, trash
ORM	Onroad mobile sources
POTW	Publicly owned treatment works
PT	Point sources
ROADS	Paved and unpaved road dust
RR	Locomotives
RWC	Woodstoves, fireplaces, inserts
SHIP	Commercial marine vessels
SOLV	Dry cleaning, graphic arts, surface coating: industrial
TILL_HARV	Agricultural tilling and harvesting

Table 4-1. Annual Statewide Emissions in Tons								
Category	**CO**	**DSPM 2.5**	**NH_3**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**
AIR	12,941.7			3,308.7	288.1	242.3	351.1	883.3
BOAT	42,242.6	21.7		3,530.4	243.4	225.0	19.8	14,265.9
CONS								50,610.5
CONST					35,574.3	3,679.1		
F_COMM	556.4		4.6	204.4	480.3	415.3	23.2	15.8
F_RES	1,803.3	43.6	778.7	4,589.0	71.6	62.6	912.4	248.2
FERT			19,243.7					
FIRE	42,064.4		692.4	679.3	4,373.3	3,706.2	348.3	9,953.7
FOOD	1,105.4				2,865.7	2,659.6		388.3
GAS_TRANS								9,582.2
GASSTN								4,956.6
LIVE			30,305.2					
MISC	372.7			28.3	96.7	90.2	2.9	71.9
NAT	146,218.8			12,108.7				624,247.2
NRM	270,638.5	2,176.0		31,467.0	3,357.2	3,203.5	86.8	31,009.3
OB_nonRES	35,761.0			1,621.2	4,730.4	4,497.8	212.6	3,198.4
OB_RES	12,914.2			557.1	2,516.1	2,114.6	73.3	1,483.3
ORM	989,606.2	3,086.3	2,637.5	164,130.2	6,892.7	5,328.1	601.2	78,180.4
POTW			16.9					84.8
PT	61,083.3	41.9	477.4	26,360.9	4,687.4	3,542.7	13,809.0	10,422.0
ROADS					62,619.2	8,965.0		
RR	2,536.5	428.0	0.3	15,025.6	429.9	428.0	94.9	809.8
RWC	114,415.8		960.5	1,803.4	16,566.3	16,560.2	270.8	19,213.9
SHIP	2,521.2	1,021.1	1.4	20,486.2	1,212.7	1,021.3	11,528.9	782.0
SOLV								21,461.1
TILL_HARV					83,951.8	16,431.1		
Totals	**1,736,782**	**6,818**	**55,119**	**285,900**	**230,957**	**73,173**	**28,335**	**881,868**

Table 4-2. Annual Statewide Emissions Source Percentages									
Category	**CO**	**DSPM 2.5**	**NH_3**	**NO_X**	**PM_{10}**	**$PM_{2.5}$**	**SO_2**	**VOC**	**VOC w/o NAT**
AIR	0.75%			1.16%	0.12%	0.33%	1.24%	0.10%	0.34%
BOAT	2.43%	0.32%		1.23%	0.11%	0.31%	0.07%	1.62%	5.54%
CONS								5.74%	19.65%
CONST					15.40%	5.03%			
F_COMM	0.03%		0.01%	0.07%	0.21%	0.57%	0.08%	0.00%	0.01%
F_RES	0.10%	0.64%	1.41%	1.61%	0.03%	0.09%	3.22%	0.03%	0.10%
FERT			34.91%						
FIRE	2.42%		1.26%	0.24%	1.89%	5.06%	1.23%	1.13%	3.86%
FOOD	0.06%				1.24%	3.63%		0.04%	0.15%
GAS_TRANS								1.09%	3.72%
GASSTN								0.56%	1.92%
LIVE			54.98%						
MISC	0.02%			0.01%	0.04%	0.12%	0.01%	0.01%	0.03%
NAT	8.42%			4.24%				70.79%	
NRM	15.58%	31.91%		11.01%	1.45%	4.38%	0.31%	3.52%	12.04%
OB_nonRES	2.06%			0.57%	2.05%	6.15%	0.75%	0.36%	1.24%
OB_RES	0.74%			0.19%	1.09%	2.89%	0.26%	0.17%	0.58%
ORM	56.98%	45.26%	4.79%	57.41%	2.98%	7.28%	2.12%	8.87%	30.35%
POTW			0.03%					0.01%	0.03%
PT	3.52%	0.61%	0.87%	9.22%	2.03%	4.84%	48.73%	1.18%	4.05%
ROADS					27.11%	12.25%			
RR	0.15%	6.28%	0.00%	5.26%	0.19%	0.58%	0.33%	0.09%	0.31%
RWC	6.59%		1.74%	0.63%	7.17%	22.63%	0.96%	2.18%	7.46%
SHIP	0.15%	14.98%	0.00%	7.17%	0.53%	1.40%	40.69%	0.09%	0.30%
SOLV								2.43%	8.33%
TILL_HARV					36.35%	22.46%			

Table 4-3. County PM_{10} Emissions Estimates																	
County	AIR	BOAT	CONST	F COMM	F_ RES	FIRE	FOOD	MISC	NRM	OB Non RES	OB RES	ORM	PT	ROADS	RR	RWC	SHIP	TILL HARV
Adams	2	1	23	1	0	43	8	0	56	72	5	58		2,628	35	14		10,571
Asotin	0	1	39	1	0		4	0	11	10	6	14		391		23	0	716
Benton	5	9	658	12	0	32	54	4	87	47	6	179	44	853	34	162	1	6,817
Chelan	3	5	310	5	0	282	36	1	44	247	23	80	546	849	12	201		15
Clallam	5	4	232	4	0	93	31	0	39	130	40	69	76	444		226	387	17
Clark	4	14	1,889	21	2	0	125	4	159	18	150	338	189	668	25	1,144	16	368
Columbia	0	0	22	0	0	0	0	0	56	559	1	6		862	0	13	1	2,194
Cowlitz	3	5	523	5	0	7	35	2	48	24	38	157	182	381	23	290	37	109
Douglas	3	2	142	1	0	107	9	1	38	12	11	42	6	4,942	4	101	0	5,777
Ferry	0	0	17	0	0	8	2	0	26	18	8	12		1,212	1	23		46
Franklin	4	3	468	3	0	102	15	1	63	338	13	78		1,490	26	58	1	4,470
Garfield	0	0	6	0	0	257	1	0	16	190	1	6		964		2	0	1,946
Grant	17	5	542	4	0	52	24	1	104	137	25	123		5,045	10	74	0	7,288
Grays	3	3	357	3	0	134	30	1	40	135	35	83	410	603	1	206	10	130
Island	2	5	198	3	1		26	1	25	0	65	56	18	329		237	69	51
Jefferson	4	3	123	1	0	1,103	12	1	29	56	34	41	314	541		102	49	3
King	99	55	12,366	213	32	24	1,147	24	803	0	409	1,868	97	5,997	29	3,993	216	134
Kitsap	9	10	408	13	4		87	3	85		112	205	18	828	0	896	49	3
Kittitas	4	1	224	2	0	54	28	1	37	58	15	148		670	1	121	0	383
Klickitat	3	1	103	1	0	750	6	0	32	187	12	28	110	1,191	47	61	1	1,676
Lewis	7	3	206	4	0	0	30	2	41	101	71	137	525	554	15	215		216
Lincoln	1	1	26	0	0	21	4	0	73	49	3	35		3,206	21	11	0	12,564
Mason	6	5	238	2	0	8	16	2	24	23	64	59	85	518	1	172	0	14
Okanogan	5	2	217	2	0	156	16	1	27	155	13	60		2,321	2	119		560
Pacific	0	1	81	1	0	0	12	1	16	70	12	25	14	289		68	14	5
Pend	0	1	528	0	0	12	4	0	20	225	5	16	4	1,319	1	39		58

Table 4-3. County PM_{10} Emissions Estimates																		
County	**AIR**	**BOAT**	**CONST**	**F COMM**	**F_ RES**	**FIRE**	**FOOD**	**MISC**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**ROADS**	**RR**	**RWC**	**SHIP**	**TILL HARV**
Pierce	11	25	3,677	48	7	258	292	11	360	1	273	762	226	1,625	20	1,470	74	77
San Juan	16	2	112	1	0	0	12	0	14	0	42	9		153		55	5	7
Skagit	6	8	473	7	1	13	53	3	64	58	61	171	429	606	5	329	42	523
Skamania	0	0	25	0	0	36	3	0	21	12	7	15		144	20	33	0	1
Snohomish	26	24	2,238	37	5	20	267	8	252	10	237	668	51	1,382	18	2,523	87	216
Spokane	14	16	4,810	36	7	14	173	6	164	99	101	469	180	6,712	42	1,353	0	4,156
Stevens	2	2	387	1	0	204	14	1	37	66	35	49	79	2,974	1	125	0	243
Thurston	3	9	1,427	14	2	57	94	4	91	7	143	279	1	799	12	730	1	34
Wahkiakum	0	0	31	0	0	0	0	0	1	5	5	5		118		13	26	10
Walla Walla	2	1	186	4	1	472	19	1	62	1,022	13	56	127	983	11	157	1	5,798
Whatcom	5	8	1,234	13	2	0	84	3	85	53	359	195	924	843	6	581	124	655
Whitman	5	1	71	2	1		9	1	111	476	7	44	3	2,786	5	43	1	14,565
Yakima	4	5	960	13	2	53	85	6	95	60	55	245	29	4,398	3	583		1,540
Totals	**288**	**243**	**35,574**	**480**	**72**	**4,373**	**2,866**	**97**	**3,357**	**4,730**	**2,516**	**6,893**	**4,687**	**62,619**	**430**	**16,566**	**1,213**	**83,952**

Table 4-4. County $PM_{2.5}$ Emissions Estimates																		
County	AIR	BOAT	CONST	F COMM	F RES	FIRE	FOOD	MISC	NRM	OB Non RES	OB RES	ORM	PT	ROADS	RR	RWC	SHIP	TILL HARV
Adams	2	1	2	1	0	36	8	0	54	70	4	51		293	35	14		2,072
Asotin	0	1	4	1	0		3	0	10	9	5	11		44		23	0	140
Benton	4	8	66	11	0	27	50	4	84	44	5	141	8	154	34	162	1	1,350
Chelan	2	5	31	5	0	239	33	1	42	234	19	64	546	142	12	201		3
Clallam	4	4	24	3	0	79	29	0	36	114	34	56	66	104		226	312	3
Clark	3	13	198	19	2	0	116	4	152	16	130	259	169	161	25	1,144	15	73
Columbia	0	0	3	0	0	0	0	0	52	555	1	5		93	0	13	1	424
Cowlitz	2	5	55	5	0	6	33	2	46	21	33	130	172	93	23	290	34	22
Douglas	3	2	14	1	0	90	8	1	37	11	9	33	4	520	4	100	0	1,133
Ferry	0	0	2	0	0	7	2	0	24	17	6	10		132	1	23		9
Franklin	4	3	49	3	0	87	14	1	61	331	11	62		187	26	58	1	883
Garfield	0	0	1	0	0	218	1	0	15	186	1	5		104		2	0	381
Grant	15	5	57	4	0	44	22	1	100	133	22	102		587	10	74	0	1,429
Grays	3	3	36	3	0	114	28	1	37	118	29	66	375	119	1	206	9	26
Island	2	5	20	2	1		24	1	24	0	53	45	16	81		237	55	10
Jefferson	3	2	14	1	0	935	11	1	28	49	28	33	237	95		102	39	0
King	89	51	1,256	184	28	20	1,064	23	766	0	353	1,386	85	1,126	29	3,992	189	27
Kitsap	7	10	42	11	3		80	3	81		96	157	3	169	0	895	39	0
Kittitas	3	1	23	2	0	46	26	1	35	53	13	130		126	1	120	0	74
Klickitat	2	1	11	1	0	635	5	0	30	163	10	23	46	148	47	61	1	327
Lewis	5	2	21	3	0	0	28	2	39	88	57	113	341	118	15	215		42
Lincoln	1	1	3	0	0	18	3	0	71	48	3	30		342	21	11	0	2,455
Mason	5	4	26	2	0	7	15	1	22	20	52	48	54	104	1	172	0	3
Okanogan	4	2	24	2	0	132	15	1	26	140	11	51		288	1	119		110
Pacific	0	1	9	1	0	0	11	1	15	61	10	21	7	54		68	14	1

Table 4-4. County $PM_{2.5}$ Emissions Estimates																		
County	**AIR**	**BOAT**	**CONST**	**F COMM**	**F RES**	**FIRE**	**FOOD**	**MISC**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**ROADS**	**RR**	**RWC**	**SHIP**	**TILL HARV**
Pend	0	1	65	0	0	10	4	0	19	204	4	14	4	146	1	39		10
Pierce	8	23	379	41	6	218	271	10	344	1	236	563	116	362	19	1,470	63	15
San Juan	15	2	12	1	0	0	11	0	14	0	33	8		23		55	4	1
Skagit	5	8	49	6	1	11	49	3	61	52	50	138	55	137	5	329	37	103
Skamania	0	0	3	0	0	31	3	0	20	11	6	13		30	20	33	0	0
Snohomish	20	23	230	32	4	17	248	7	240	8	204	506	20	336	18	2,523	80	43
Spokane	12	15	508	31	6	12	161	6	157	88	87	358	156	825	42	1,352	0	816
Stevens	2	2	46	1	0	173	13	1	35	59	28	42	62	338	1	125	0	49
Thurston	3	8	145	12	2	48	87	3	87	6	119	219	1	182	12	730	1	6
Wahkiakum	0	0	4	0	0	0	0	0	1	4	4	4		17		13	25	2
Walla Walla	2	1	19	3	1	400	18	1	60	1,012	11	44	128	135	11	157	1	1,129
Whatcom	4	7	126	11	1	0	78	2	81	46	283	155	864	182	6	581	99	130
Whitman	4	1	7	2	1		9	0	108	474	6	36	3	314	5	43	1	2,831
Yakima	4	5	98	11	2	45	79	5	91	52	48	196	4	552	3	583		303
Totals	**242**	**225**	**3,679**	**415**	**63**	**3,706**	**2,660**	**90**	**3,204**	**4,498**	**2,115**	**5,328**	**3,543**	**8,965**	**428**	**16,560**	**1,021**	**16,431**

Table 4-5. County $DSPM_{2.5}$ Emissions Estimates							
County	**BOAT**	**F_RES**	**NRM**	**ORM**	**PT**	**RR**	**SHIP**
Adams	0.06	0.11	51.61	33.69		35.17	
Asotin	0.10	0.05	7.21	4.97			0.32
Benton	0.82	0.15	68.33	84.50		33.74	1.14
Chelan	0.46	0.06	20.53	34.04		11.58	
Clallam	0.36	0.17	15.43	30.40	0.30		312.10
Clark	1.22	0.89	108.75	147.34	7.01	24.70	15.28
Columbia	0.03	0.15	15.79	3.25		0.14	0.50
Cowlitz	0.46	0.13	24.37	83.07	0.03	22.68	33.70
Douglas	0.17	0.05	32.46	17.70		4.17	0.00
Ferry	0.03	0.08	3.09	5.53		0.93	
Franklin	0.26	0.15	56.57	34.60		25.73	0.92
Garfield	0.01	0.09	13.22	3.35			0.42
Grant	0.48	0.11	84.81	61.80		10.24	0.00
Grays	0.25	0.32	15.12	38.51	5.00	0.94	9.46
Island	0.48	0.60	15.62	25.02			55.20
Jefferson	0.23	0.33	16.37	18.56	10.00		38.90
King	4.92	20.82	503.48	831.09		28.71	189.02
Kitsap	0.93	2.81	54.73	83.59		0.45	39.06
Kittitas	0.13	0.31	18.73	87.66		0.97	0.00
Klickitat	0.06	0.22	16.29	13.49		46.57	1.17
Lewis	0.23	0.19	21.24	67.83	0.51	14.96	
Lincoln	0.10	0.24	64.43	18.65		20.67	0.00
Mason	0.42	0.18	10.28	27.36		0.73	0.01
Okanogan	0.17	0.17	15.49	27.53		1.48	
Pacific	0.10	0.16	3.75	12.57			13.82
Pend	0.11	0.02	3.62	6.74		1.05	
Pierce	2.23	3.94	250.05	317.17	1.00	19.47	62.63
San Juan	0.20	0.25	6.21	3.41			3.64
Skagit	0.74	0.52	33.96	82.81	2.00	4.69	36.51
Skamania	0.03	0.05	2.92	7.37		20.37	0.44
Snohomish	2.18	2.16	149.42	291.48		17.67	79.66
Spokane	1.43	4.17	115.02	186.67		41.99	0.00
Stevens	0.20	0.24	18.63	20.05		1.37	0.00
Thurston	0.76	0.78	62.97	129.53		11.96	0.84
Wahkiakum	0.04	0.05	0.75	2.32			24.65
Walla Walla	0.11	0.38	50.64	24.78		10.91	1.25
Whatcom	0.68	0.65	53.18	89.77	16.00	5.79	99.39
Whitman	0.09	0.43	105.78	21.01		4.90	1.02
Yakima	0.48	1.40	65.15	107.07		3.22	
Totals	**21.75**	**43.57**	**2,175.99**	**3,086.29**	**41.85**	**427.96**	**1,021.07**

Table 4-6. County SO_2 Emissions Estimates														
County	**AIR**	**BOAT**	**F COMM**	**F RES**	**FIRE**	**MISC**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**RR**	**RWC**	**SHIP**
Adams	0.3	0.1	0.0	2.4	4.1	0.0	1.3	4.0	0.2	4.9		8.0	0.3	
Asotin	0.0	0.1	0.0	1.1		0.0	0.2	0.3	0.2	1.1			0.5	0.1
Benton	0.6	0.7	0.6	3.3	3.0	0.1	2.2	1.2	0.3	15.7	12.6	6.3	3.4	0.4
Chelan	2.6	0.4	0.3	1.2	18.8	0.0	0.9	0.1	0.7	6.4	2,906.1	2.3	3.3	
Clallam	0.8	0.3	0.2	3.5	6.4	0.0	0.8		1.2	5.6	124.3		3.7	4,608.7
Clark	0.5	1.1	1.0	19.5	0.0	0.2	4.4		5.6	30.1	21.3	5.3	18.6	82.5
Columbia	0.0	0.0	0.0	3.1	0.0	0.0	1.0	49.5	0.0	0.5		0.0	0.2	0.2
Cowlitz	0.3	0.4	0.3	2.7	0.7	0.0	1.2		1.3	12.8	790.6	5.9	4.7	199.2
Douglas	1.8	0.2	0.1	1.1	9.9	0.0	0.9	0.3	0.4	3.6	4.0	0.7	1.6	0.0
Ferry	0.0	0.0	0.0	1.6	0.7	0.0	0.4		0.1	0.9		0.3	0.4	
Franklin	4.7	0.2	0.2	3.1	9.7	0.0	1.6	17.6	0.5	7.0		4.9	1.2	0.4
Garfield	0.0	0.0	0.0	1.8	23.7	0.0	0.4	16.9	0.0	0.6			0.0	0.2
Grant	5.3	0.4	0.2	2.2	4.9	0.0	2.4	5.7	0.8	10.1		2.1	1.5	0.0
Grays	0.4	0.2	0.2	6.6	9.0	0.0	0.8	0.0	0.9	7.1	227.7	0.3	3.3	14.7
Island	0.3	0.4	0.1	12.6		0.0	0.6	0.0	1.4	4.7	1.0		3.8	821.5
Jefferson	0.5	0.2	0.1	6.8	68.1	0.0	0.7	0.0	0.6	3.3	150.0		1.7	580.1
King	266.8	4.5	10.3	432.7	1.5	0.8	23.2		15.5	172.6	235.9	6.1	65.3	1,225.4
Kitsap	1.2	0.8	0.6	58.0		0.1	2.2		4.3	18.3		0.1	13.8	584.2
Kittitas	0.5	0.1	0.1	6.5	5.7	0.0	0.7	0.8	0.4	11.5		0.2	2.0	0.0
Klickitat	0.4	0.1	0.0	4.6	72.5	0.0	0.6	0.0	0.3	2.3	21.0	8.6	1.0	0.5
Lewis	0.8	0.2	0.2	4.0	0.0	0.0	1.0		1.2	11.2	1,212.3	4.0	3.5	
Lincoln	0.2	0.1	0.0	4.9	2.2	0.0	1.7	2.9	0.1	2.7		4.3	0.2	0.0
Mason	0.4	0.4	0.1	3.8	0.7	0.0	0.5		1.2	5.0		0.2	2.8	0.1
Okanogan	0.7	0.2	0.1	3.4	13.7	0.0	0.6	0.2	0.5	4.5		0.5	1.9	
Pacific	0.1	0.1	0.0	3.2	0.0	0.0	0.2		0.4	2.1			1.1	16.4
Pend	0.0	0.1	0.0	0.4	1.0	0.0	0.3		0.2	1.2	13.0	0.3	0.6	

Table 4-6. County SO_2 Emissions Estimates														
County	**AIR**	**BOAT**	**F COMM**	**F RES**	**FIRE**	**MISC**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**RR**	**RWC**	**SHIP**
Pierce	1.4	2.0	2.3	83.0	17.6	0.4	9.7		10.3	68.6	363.6	5.1	24.3	608.2
San Juan	14.8	0.2	0.0	5.2	0.0	0.0	0.3		0.4	0.6			0.9	54.7
Skagit	1.1	0.7	0.4	11.3	0.8	0.1	1.5	0.2	1.5	14.3	875.0	0.9	5.3	184.0
Skamania	0.0	0.0	0.0	1.1	2.3	0.0	0.3		0.2	1.2		3.8	0.5	0.2
Snohomish	5.1	2.0	1.8	47.0	1.6	0.3	7.3		8.9	59.4	333.7	3.4	40.9	175.8
Spokane	26.0	1.3	1.8	87.4	1.3	0.2	4.6	0.1	3.9	38.7	21.6	9.5	22.0	0.0
Stevens	0.4	0.2	0.1	5.0	13.2	0.0	0.8	0.0	0.6	3.5	10.0	0.4	2.0	0.0
Thurston	0.4	0.7	0.7	16.9	4.6	0.1	2.4	0.0	3.7	24.4		3.4	11.9	15.4
Wahkiakum	0.0	0.0	0.0	1.0	0.0	0.0	0.0		0.1	0.4			0.2	99.7
Walla Walla	0.9	0.1	0.2	8.0	45.4	0.0	1.5	70.5	0.5	4.8	794.9	4.5	2.5	0.5
Whatcom	7.4	0.6	0.6	14.3	0.0	0.1	2.2	0.1	2.6	16.3	5,690.5	1.2	9.4	2,255.7
Whitman	2.7	0.1	0.1	8.8		0.0	2.8	41.9	0.3	3.8		1.6	0.9	0.4
Yakima	1.7	0.4	0.6	29.1	5.2	0.1	2.4		2.0	19.4		0.7	9.5	
Totals	**351.1**	**19.8**	**23.2**	**912.4**	**348.3**	**2.9**	**86.8**	**212.6**	**73.3**	**601.2**	**13,809.0**	**94.9**	**270.8**	**11,528.9**

Table 4-7. County NO_X Emissions Estimates															
County	AIR	BOAT	F COMM	F RES	FIRE	MISC	NAT	NRM	OB Non RES	OB RES	ORM	PT	RR	RWC	SHIP
Adams	1.4	9.7	0.4	8.4	9.0	0.1	824.7	617.7	21.7	1.1	1,779.3		1,197.7	2.3	
Asotin	0.0	16.0	0.4	20.7		0.1	214.8	95.4	2.7	1.3	351.4			3.7	9.9
Benton	3.0	131.1	5.3	42.7	6.4	0.9	639.6	888.2	62.4	1.6	4,627.8	227.7	1,150.1	26.6	35.6
Chelan	42.1	74.6	2.3	6.1	30.3	0.3	245.8	302.7	52.2	5.1	2,077.7	62.8	406.0	21.4	
Clallam	4.4	58.7	1.6	12.9	11.0	0.3	73.5	238.3	33.3	9.1	1,873.6	156.0		24.1	5,768.9
Clark	2.5	197.9	9.1	215.3	0.1	1.6	80.4	1,550.2	4.7	29.6	7,979.4	598.6	878.7	121.9	497.6
Columbia	0.0	4.1	0.1	2.0	0.0	0.0	314.9	227.4	247.0	0.3	185.1		5.9	1.4	15.6
Cowlitz	1.7	74.3	2.3	12.8	1.4	0.5	59.3	389.4	6.1	8.0	4,281.1	3,616.3	788.7	30.9	1,108.9
Douglas	13.9	28.1	0.6	2.8	21.8	0.2	544.6	396.2	12.8	2.2	1,079.5	9.0	160.3	10.7	0.0
Ferry	0.2	4.9	0.1	2.2	1.6	0.0	213.5	61.6	4.3	2.0	342.6	0.1	41.2	2.5	
Franklin	29.3	41.0	1.3	24.5	21.8	0.3	591.9	697.8	101.8	2.5	2,094.3		910.8	9.5	28.7
Garfield	0.0	1.6	0.0	1.5	51.6	0.0	339.4	158.5	89.0	0.2	178.8			0.4	13.1
Grant	41.0	77.6	1.8	5.9	10.8	0.4	978.0	1,050.8	54.5	5.5	3,448.9		358.4	12.2	0.1
Grays	2.2	41.2	1.3	23.3	14.6	0.4	91.1	245.3	34.7	8.1	2,224.3	643.7	41.4	21.9	297.9
Island	2.6	78.8	1.1	81.2		0.4	25.3	222.3	0.3	15.8	1,467.6	8.0		25.2	1,056.8
Jefferson	2.5	36.7	0.6	24.8	98.7	0.2	66.0	223.5	14.5	8.8	1,105.0	473.0		10.8	748.1
King	2,546.2	800.6	90.5	1,634.8	2.1	7.7	125.3	8,134.3	0.1	81.1	39,598.2	2,026.8	1,045.0	442.9	4,047.8
Kitsap	8.1	151.2	5.4	172.4		1.0	30.8	773.1		22.3	4,950.9	0.3	19.7	93.2	747.8
Kittitas	2.7	21.6	0.9	33.1	13.6	0.2	291.3	253.0	13.9	3.5	4,227.0		32.8	12.8	0.0
Klickitat	1.8	9.9	0.3	10.8	163.3	0.1	465.8	214.6	48.4	3.0	807.5	153.8	1,579.1	6.5	36.5
Lewis	4.2	38.2	1.5	24.1	0.0	0.4	125.1	313.0	26.1	17.8	3,691.3	7,611.0	524.0	22.9	
Lincoln	0.8	15.8	0.2	8.3	5.3	0.0	822.5	769.2	16.0	0.8	1,009.9		713.6	1.8	0.0
Mason	2.4	67.7	0.9	19.8	1.4	0.3	45.7	159.5	5.8	16.0	1,657.6	58.0	32.2	18.4	0.2
Okanogan	3.4	27.0	0.8	6.8	28.9	0.2	755.9	208.5	36.7	2.6	1,647.9		65.1	12.7	
Pacific	0.3	16.3	0.4	5.5	0.0	0.1	49.3	66.2	18.1	2.5	722.3	66.0		7.3	433.5
Pend	0.1	17.2	0.2	1.9	1.9	0.1	73.9	63.8	55.2	0.9	460.1	27.0	46.2	4.2	

Table 4-7. County NO_X Emissions Estimates															
County	**AIR**	**BOAT**	**F COMM**	**F RES**	**FIRE**	**MISC**	**NAT**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**RR**	**RWC**	**SHIP**
Pierce	7.6	362.0	20.4	500.0	29.4	3.4	101.7	3,573.4	0.4	53.9	16,788.9	1,178.6	699.0	161.5	1,320.8
San Juan	219.9	32.8	0.3	11.9	0.0	0.1	15.0	93.2	0.0	11.6	257.5			5.9	68.4
Skagit	4.9	120.6	3.1	121.6	1.3	0.6	131.8	500.5	15.5	14.1	4,466.3	3,262.6	172.5	35.1	900.3
Skamania	0.0	4.9	0.1	3.9	3.5	0.0	59.3	56.8	3.4	1.7	433.5		691.0	3.5	13.7
Snohomish	41.3	354.4	15.8	520.4	3.0	2.7	111.8	2,486.6	2.5	46.8	15,235.8	866.2	611.0	264.9	1,758.4
Spokane	220.3	231.8	15.4	429.7	2.8	1.9	598.6	1,688.2	25.2	20.4	10,727.4	566.1	1,469.3	144.1	0.0
Stevens	1.8	32.9	0.6	26.0	20.7	0.2	280.3	261.1	15.3	8.9	1,383.9	472.0	55.1	13.3	0.0
Thurston	2.1	123.9	6.0	188.5	9.2	1.1	59.2	876.5	1.9	32.7	6,769.6	5.0	417.0	77.8	10.6
Wahkiakum	0.0	5.9	0.1	1.3	0.0	0.0	24.5	10.7	1.3	1.2	130.5			1.3	787.5
Walla Walla	6.7	17.1	1.6	37.4	101.9	0.3	684.7	635.2	351.3	2.6	1,512.6	945.9	381.6	16.7	39.1
Whatcom	52.6	110.8	5.5	207.4	0.0	0.8	161.1	786.7	14.7	99.1	4,941.5	3,314.3	204.2	61.9	708.6
Whitman	22.4	14.1	0.8	24.4		0.2	1,011.1	1,262.3	212.0	1.5	1,157.2	8.0	206.3	7.0	31.9
Yakima	12.4	77.4	5.4	112.1	11.8	1.2	781.2	915.2	15.5	11.1	6,456.2	3.9	122.0	62.2	
Totals	**3,308.7**	**3,530.4**	**204.4**	**4,589.0**	**679.3**	**28.3**	**12,108.7**	**31,467.0**	**1,621.2**	**557.1**	**164,130.2**	**26,360.9**	**15,025.6**	**1,803.4**	**20,486.2**

Table 4-8. County VOC Emissions Estimates

County	AIR	BOAT	F CONS	F COMM	F RES	FIRE	FOOD	GAS TRANS	GASSTN	MISC	NAT	NRM	OB Non RES	OB RES	ORM	POTW	PT	RR	RWC	SHIP	SOLV
Adams	3	42	2,272	0	0	92	1	56	31	0	8,968	134	67	3	472	0		65	15		39
Asotin	0	69	111	0	1		0	9	25	0	6,066	110	9	4	275	0			24	0	71
Benton	7	562	4,260	0	2	71	8	308	215	3	11,152	501	36	7	2,350	2	83	62	172	1	378
Chelan	5	301	1,023	0	0	670	5	81	109	1	33,013	720	79	14	1,191	1	266	22	239		211
Clallam	7	235	345	0	1	218	4	61	101	0	15,099	609	40	25	1,137	1	26		269	219	279
Clark	6	784	1,958	1	12	1	17	242	243	3	6,902	1,247	5	82	3,919	5	138	49	1,362	20	1,112
Columbia	0	18	68	0	0	0	0	5	7	0	7,987	1,568	501	1	84	0		0	15	0	8
Cowlitz	4	298	549	0	1	16	5	696	138	2	11,443	592	7	22	1,649	2	671	43	346	46	390
Douglas	9	113	521	0	0	232	1	241	52	0	12,035	186	10	6	582	0	5	9	120	0	74
Ferry	0	20	58	0	0	17	0	40	13	0	32,597	866	5	5	172	0		2	27		13
Franklin	16	176	2,784	0	1	221	2	36	101	1	8,031	201	313	7	1,060	1		51	61	1	196
Garfield	0	7	37	0	0	562	0	4	4	0	5,214	91	164	0	63	0			3	0	4
Grant	40	333	4,965	0	0	112	3	290	133	1	15,811	607	123	15	1,516	1		19	79	0	217
Grays	5	165	361	0	1	318	4	50	94	1	17,219	690	39	21	1,139	1	141	2	245	8	236
Island	3	316	395	0	4		3	48	48	1	1,894	234	0	41	997	0	43		282	40	166
Jefferson	5	147	144	0	1	2,658	2	64	48	1	15,659	390	17	22	590	0	44		121	28	66
King	509	3,210	8,887	7	90	58	154	2,731	729	17	18,485	6,799	0	227	16,831	31	1,024	59	4,243	166	7,216
Kitsap	12	606	1,167	0	9		12	372	113	3	5,666	691		63	2,933	2	142	1	1,170	28	565
Kittitas	6	87	281	0	2	113	4	73	65	0	23,325	578	26	10	1,078	1		2	143	0	92
Klickitat	4	43	199	0	1	1,611	1	56	31	0	22,081	557	55	8	406	0	201	86	72	1	68
Lewis	9	153	389	0	1	1	4	65	131	2	20,914	501	29	44	1,588	1	221	28	256		229
Lincoln	2	64	210	0	0	44	0	53	21	0	12,863	281	44	2	319	0		38	12	0	19
Mason	11	272	276	0	1	18	2	33	92	1	11,635	376	7	41	966	0	166	1	205	0	131
Okanogan	7	109	790	0	0	345	2	254	70	1	58,641	328	54	8	832	0		3	142		78
Pacific	1	65	126	0	0	1	2	19	34	1	8,288	383	20	7	370	0	35		81	12	41

Table 4-8. County VOC Emissions Estimates																					
County	**AIR**	**BOAT**	**F CONS**	**F COMM**	**F RES**	**FIRE**	**FOOD**	**GAS TRANS**	**GASSTN**	**MISC**	**NAT**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**POTW**	**PT**	**RR**	**RWC**	**SHIP**	**SOLV**
Pend	0	69	79	0	0	26	1	8	24	0	22,892	606	85	3	275	0	142	2	47		22
Pierce	14	1,451	3,631	2	28	608	40	726	314	8	14,978	2,406	0	150	8,073	8	403	37	1,659	46	2,144
San Juan	37	132	88	0	0	0	2	98	31	0	1,384	212	0	28	248	0			66	3	30
Skagit	10	484	1,245	0	6	30	7	109	155	2	15,490	878	25	37	2,101	1	1,297	10	392	32	356
Skamania	0	19	64	0	0	87	0	6	6	0	19,649	673	4	4	221	0		38	39	0	33
Snohomish	35	1,421	3,339	1	28	47	36	726	299	6	17,889	2,266	3	130	7,133	8	943	33	3,046	69	3,339
Spokane	65	933	2,307	1	24	31	24	289	366	4	18,002	1,300	32	59	5,603	8	260	80	1,610	0	1,472
Stevens	3	132	255	0	1	487	2	64	80	0	36,144	503	20	23	870	0	147	2	149	0	114
Thurston	5	497	1,196	0	10	128	13	169	246	3	7,930	671	2	86	3,411	2	197	22	869	0	580
Wahkiakum	0	24	43	0	0	0	0	4	3	0	3,332	8	1	3	70	0			15	32	7
Walla Walla	6	73	1,125	0	2	1,016	3	251	76	1	6,620	378	916	7	837	1	1,788	20	187	1	160
Whatcom	17	444	1,174	0	11	0	12	679	333	2	18,022	859	17	237	2,672	3	1,710	11	692	27	574
Whitman	13	61	457	0	1		1	68	42	0	7,186	200	427	4	517	1		9	45	1	114
Yakima	10	332	3,434	0	6	112	11	497	334	4	43,742	810	17	31	3,626	2	331	6	694		617
Totals	**883**	**14,266**	**50,610**	**16**	**248**	**9,954**	**388**	**9,582**	**4,957**	**72**	**624,247**	**31,009**	**3,198**	**1,483**	**78,180**	**85**	**10,422**	**810**	**19,214**	**782**	**21,461**

Table 4-9. County CO Emissions Estimates																
County	AIR	BOAT	F COMM	F RES	FIRE	FOOD	MISC	NAT	NRM	OB Non RES	OB RES	ORM	PT	RR	RWC	SHIP
Adams	118	118		3	386	3	1	2,539	1,103	574	24	7,576		213	95	
Asotin	2	195	1	9		1	1	1,264	678	60	24	3,143			153	2
Benton	250	1,589	14	17	298	22	17	2,808	4,834	504	35	28,458	112	203	1,095	7
Chelan	76	893	6	2	2,851	14	5	6,395	3,487	1,748	118	14,164	16,723	68	1,400	
Clallam	250	700	4	4	926	12	2	4,296	3,294	699	213	13,470	1,070		1,578	549
Clark	215	2,364	25	89	4	48	16	2,121	12,608	89	538	48,797	588	146	7,981	70
Columbia	1	50	0	1	0	0	0	1,870	3,355	5,163	8	1,085		1	89	3
Cowlitz	125	887	6	5	68	14	8	3,361	3,718	117	162	22,852	2,507	137	2,026	150
Douglas	133	336	2	1	974	3	3	2,886	1,247	108	41	7,143		24	701	0
Ferry	15	58	0	1	73	1	0	6,230	1,866	110	60	2,192	0	4	161	
Franklin	254	497	4	10	926	6	5	2,082	2,025	2,927	45	12,966		153	391	6
Garfield	1	19	0	0	2,358	0	0	1,294	384	1,592	5	864			16	3
Grant	715	941	5	2	471	9	4	4,004	3,598	1,152	123	19,257		60	502	0
Grays	160	492	4	8	1,354	12	6	4,861	3,367	660	204	13,786	731	4	1,435	56
Island	92	941	3	26		10	5	568	2,435	2	421	11,410	10		1,652	93
Jefferson	172	438	2	7	11,333	5	4	4,414	1,778	276	251	7,254	735		710	66
King	4,138	9,560	247	657	246	439	89	4,962	90,991	1	1,484	221,180	1,474	169	26,750	552
Kitsap	420	1,806	15	63		33	13	1,729	7,674		409	36,652		2	6,332	66
Kittitas	203	258	3	11	470	11	2	5,093	2,311	309	87	17,483		6	841	0
Klickitat	127	121	1	4	6,742	2	2	3,990	1,735	919	81	5,067	303	281	423	7
Lewis	304	456	4	9	2	12	9	6,009	3,034	496	504	20,710	958	89	1,502	
Lincoln	67	189	0	3	185	1	0	3,020	1,605	380	18	4,861		123	74	0
Mason	264	809	2	6	77	6	6	3,502	2,106	111	442	11,675	153	3	1,202	0
Okanogan	234	323	2	2	1,452	6	3	11,433	1,706	1,022	51	10,667		6	830	
Pacific	24	194	1	2	3	5	3	2,391	1,456	344	53	4,405	56		476	84
Pend	6	206	0	1	111	2	1	4,461	1,486	1,601	18	3,364	1	5	275	

Table 4-9. County CO Emissions Estimates																
County	**AIR**	**BOAT**	**F COMM**	**F RES**	**FIRE**	**FOOD**	**MISC**	**NAT**	**NRM**	**OB Non RES**	**OB RES**	**ORM**	**PT**	**RR**	**RWC**	**SHIP**
Pierce	483	4,323	56	201	2,584	113	44	4,154	28,104	7	982	104,249	1,491	114	10,124	198
San Juan	712	392	1	3	1	5	1	429	1,394	0	363	2,780			386	6
Skagit	371	1,441	8	46	130	20	11	3,968	5,020	305	359	25,858	1,406	27	2,297	139
Skamania	3	58	0	1	369	1	0	5,143	1,607	62	39	2,622		123	229	3
Snohomish	1,241	4,232	43	206	198	104	30	4,692	27,349	47	852	91,980	437	106	17,699	256
Spokane	684	2,773	42	174	131	67	23	2,983	14,939	510	378	68,817	229	250	9,436	0
Stevens	89	393	2	10	2,071	6	3	6,988	2,137	383	256	10,602	1,361	7	872	0
Thurston	154	1,480	16	73	541	36	15	2,437	6,849	37	804	41,340	1	71	5,093	1
Wahkiakum	1	70	0	0	2	0	0	981	105	24	33	839			88	128
Walla Walla	105	207	4	15	4,255	7	4	1,925	2,381	8,449	51	9,966	863	66	1,094	8
Whatcom	336	1,324	15	78	1	33	11	4,657	7,821	265	3,137	31,227	29,870	34	4,052	64
Whitman	193	172	2	9		4	2	2,244	2,040	4,413	28	6,706		23	290	6
Yakima	203	939	15	43	470	33	23	8,035	7,012	295	213	42,136	4	18	4,069	
Totals	12,942	42,243	556	1,803	42,064	1,105	373	146,219	270,639	35,761	12,914	989,606	61,083	2,536	114,416	2,521

Table 4-10. County NH_3 Emissions Estimates											
County	**F_COMM**	**F_RES**	**FERT**	**FIRE**	**LIVE**	**ORM**	**POTW**	**PT**	**RR**	**RWC**	**SHIP**
Adams	0.01	1.40	2,089.35	6.41	1,139.32	25.70	0.04		0.01	0.87	
Asotin	0.01	4.00	203.38		141.33	4.61	0.03			1.40	0.01
Benton	0.12	7.87	1,205.08	4.94	738.14	67.30	0.39	50.54	0.01	9.97	0.02
Chelan	0.05	1.07	110.01	46.62	37.51	29.65	0.13	0.32	0.01	11.16	
Clallam	0.04	0.45	22.14	15.17	94.42	26.38	0.12			12.57	
Clark	0.21	41.85	86.73	0.07	514.53	130.63	0.99	2.34	0.01	63.59	0.16
Columbia	0.00	0.10	465.70	0.00	27.17	2.45	0.01		0.00	0.71	0.01
Cowlitz	0.05	1.83	27.65	1.13	196.10	60.96	0.34	131.77	0.00	16.14	0.33
Douglas	0.01	0.38	1,364.64	16.15	189.41	16.30	0.06	8.00		5.59	0.00
Ferry	0.00	0.08	37.54	1.21	48.58	4.45	0.00		0.01	1.28	
Franklin	0.03	4.64	1,183.14	15.37	1,949.22	33.06	0.15		0.00	3.56	0.02
Garfield	0.00	0.05	441.39	39.08	106.47	2.57	0.00			0.15	0.01
Grant	0.04	0.81	1,952.33	7.82	4,650.91	48.51	0.17		0.01	4.57	0.00
Grays	0.03	2.95	60.86	22.15	198.52	34.08	0.21	45.06	0.01	11.43	0.14
Island	0.03	5.21	21.66		95.32	19.80	0.06			13.16	
Jefferson	0.01	0.48	9.69	184.92	36.80	16.23	0.03	36.00		5.66	
King	2.06	301.66	45.43	4.02	719.80	715.09	6.21	1.59		259.14	
Kitsap	0.12	22.49	9.29		58.02	79.65	0.34		0.01	50.35	
Kittitas	0.02	3.28	176.40	7.86	249.49	54.19	0.14			6.70	0.00
Klickitat	0.01	1.42	483.99	112.05	258.00	10.78	0.03	4.00		3.37	0.02
Lewis	0.03	2.83	137.59	0.04	1,330.90	55.14	0.15	19.73	0.01	11.97	
Lincoln	0.00	1.22	1,879.35	3.09	85.12	13.17	0.02		0.02	0.67	0.00
Mason	0.02	1.44	15.36	1.28	36.43	23.02	0.08		0.01	9.58	
Okanogan	0.02	0.26	321.45	24.00	391.47	22.26	0.05		0.02	6.61	
Pacific	0.01	0.15	38.03	0.05	140.40	10.14	0.04			3.80	0.25
Pend	0.00	0.08	48.14	1.83	40.53	5.75	0.02	2.00	0.01	2.19	
Pierce	0.46	91.00	43.79	42.30	985.96	289.42	1.66	48.35	0.02	83.11	
San Juan	0.01	0.30	22.85	0.02	34.45	2.55	0.02			3.07	
Skagit	0.07	17.27	176.58	2.12	1,041.13	68.72	0.28	11.00		18.31	
Skamania	0.00	0.49	4.07	6.03	10.03	6.11	0.01			1.82	0.01
Snohomish	0.36	89.08	93.64	3.25	1,049.43	258.99	1.67	4.03		138.56	
Spokane	0.35	81.06	998.62	2.16	309.94	166.02	1.57	47.72	0.02	75.19	0.00
Stevens	0.01	3.66	223.45	33.84	256.83	17.03	0.07		0.01	6.95	0.00
Thurston	0.14	29.59	66.47	8.90	1,227.14	106.73	0.40		0.01	40.58	
Wahkiakum	0.00	0.03	11.78	0.02	92.44	1.77	0.00			0.70	0.33
Walla Walla	0.04	6.87	1,435.11	70.68	398.50	22.14	0.25	44.00	0.02	8.72	0.03
Whatcom	0.13	29.21	186.40	0.02	3,207.24	76.73	0.52	20.25	0.00	32.29	
Whitman	0.02	4.11	2,673.36		164.65	17.22	0.15		0.05	2.64	0.02
Yakima	0.12	17.99	871.23	7.81	8,053.58	92.23	0.45	0.70	0.01	32.42	
Totals	**4.65**	**778.66**	**19,243.65**	**692.41**	**30,305.24**	**2,637.52**	**16.86**	**477.41**	**0.30**	**960.53**	**1.37**

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